The Pennsylvania State University

The Graduate School

Department of Civil Engineering

A QUALITY CONTROL PROGRAM ANALYSIS

FOR

MODULAR HOUSING

A Report in

Construction Engineering and Management

by

Matthew S. Gass

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Engineering

December 1989

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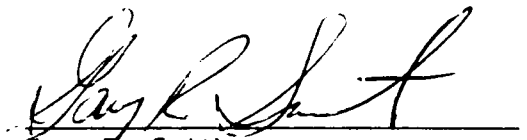

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ABSTRACT

While construction materials and methods are quite similar to those employed in the erection of a conventional, 'site-built' home, the modular housing manufacturing environment allows streamlined operations. These include stationary crews, improved material handling and storage, and repetition/standardization which should, in theory, create a product of superior quality in a short period of time. However, an analysis of an existing modular housing manufacturing facility indicates that a comprehensive plan to assure, control, and document the achievement of this superior quality is not being utilized. In short, quality is not being controlled in a manner commensurate with a modern manufacturing environment. Such a deficiency renders management incapable of monitoring its production environment and making improvements in its operation. This report constructs a quality control program and implementation strategy to enable the modular housing manufacturer to properly control and document the quality of each module produced.

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CHAPTER 1

INTRODUCTION

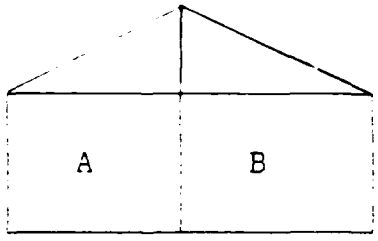
Definition of Modular Manufactured Housing

Modular homes are the most complete factory produced housing conforming to conventional building codes. (1) A modular home is a 3-dimensional structure produced in 2 or more modules or units, typically 12 to 14 feet wide and 24 to 66 feet in length. The maximum module dimensions are restricted by Federal Highway Regulations. Units leave the factory 90-95% finished, are shipped to the site, and affixed on a foundation. Site finishes for the remaining work usually require an additional two to three weeks. Once complete, they are ready for occupancy by the home owner. The units are complete with all flooring, paint, doors, windows, cabinets, lights, plumbing fixtures, electrical service and locks ready for use.

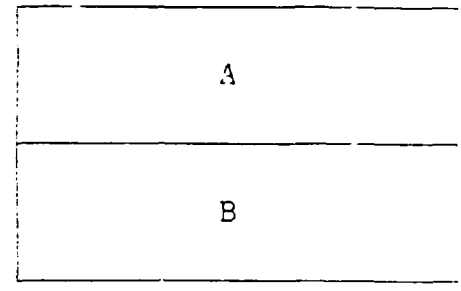
Modules may be fixed in any designed arrangement. Modular housing is identical in every aspect to site built structures, including architectural design. Figure 1.1 illustrates the stacking arrangements for typically shaped homes. Appraisal values of modular homes are also comparable with site-built construction and all qualifications for traditional mortgage financing are met. (2)

MODULE ALIGNMENTS

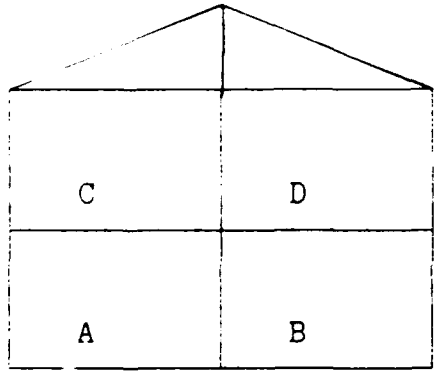
NOTE: letters indicate different modules



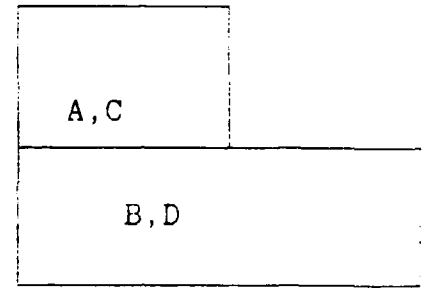
One-Story Elevation



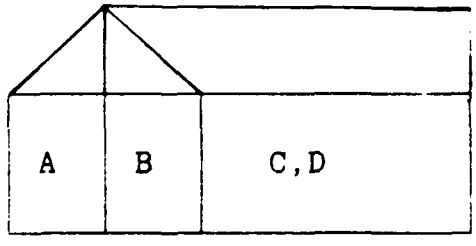
One-Story Plan



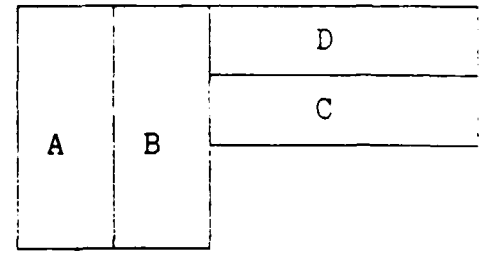
Two-Story Elevation



Two-Story Plan



One-Story "L" Elevation



One-Story "L" Plan

FIGURE 1.1

Various Typical Modular Alignments
Used by the Manufacturer

Governing Regulations

Although produced in a factory, modular homes are constructed to conventional building code standards. The state and local regulations of the final destination may modify some standard requirements which the manufacturer must include in its product. Active debate on establishing a single Federal regulation pre-empting state and local regulation may change the complex code compliance system. (3) This debate, while significant in terms of cost and time to the manufacturer and consumer, does not directly impact the quality control problem. Manufacturers have had to contend with a wide variety of requirements over and above the standard codes. Therefore, units are built to a "superset" of specifications to cover many minor code compliance items. Modular homes are structurally "over-built" to maintain structural integrity during highway and setting transport. Therefore compliance with the various codes and requirements is not at issue for quality control. Varying requirements are more of a "nuisance" rather than a significant burden to the manufacturer provided they are identified on the original production drawings. (4)

The most widely used codes are: Building Officials and Code Administration International (BOCA), International Conference of Building Officials (ICBO), Southern Building Code Congress International (SBCC), National Electric Code (NEC), and National Fire Protection Association (NFPA). These apply in most states, to any

home, whether it is site-built or factory produced. These regulations govern all basic structural, mechanical, and electrical requirements to ensure building stability, sanitation, fire resistance, and general public safety and welfare. (5)

The basic codes, BOCA, ICBO, AND SBCC are very similar to one another. Their acceptance is regional. BOCA is used in the mid-Atlantic and New England states, the ICBO in the western states, and the SBCC in the southern states. (6)

A newer code, the Council of American Building Officials (CABO) code, is a joint product of BOCA, ICBO, and SBCC. Its purpose is to be a nationwide code that applies specifically to one and two-family residential dwellings. Its acceptance is not universal, though it is used by many municipalities as a local code. (7)

The State of the Industry

The industry has grown appreciably in recent years. In 1988, modular producers accounted for 6% of the nation's new housing construction. Overall, the industry has experienced a 46% increase in sales since 1982. (8) With this growth, quality and versatility are becoming more commonplace. Modular homes are appearing as ranches, bi-levels, split levels, two-stories, cape cods, chalets, beach houses, and colonial mansions. Apartments, townhouses, and small commercial buildings are also built by modular manufacturers. The home buyer can choose a quality built product, through a builder,

in a wide range of sizes and styles without sacrificing personal tastes. (9,10)

Modular construction benefits the site builder through risk reduction. Since most of the work is completed in the factory, the builder shifts much of the labor and material risk to the manufacturer. Sub-contract problems are greatly reduced. Interest expenses are also greatly reduced without the up-front labor and material cost burden. The delivery time for a manufactured home is much quicker than for a site-built home, which reduces the loan construction period. (2,8) The builder does retain the foundation and site work responsibilities.

The Advantage of Quality Control

Although the modular manufacturer constructs a house in much the same manner as the site builder, controlled conditions in an indoor environment offer a 12 month uninterrupted construction period.(9) Purchasing large quantities of good quality materials, streamlined work activities, simple well defined tasks, more advanced assembly equipment (floor jigs, pneumatic nail guns), and the capability to apply more stringent quality control standards, are examples of opportunities afforded a manufacturer for quality control.

Quality control standards hold a major role in production. Since most assembly of a modular home occurs within a single plant, consistent and thorough work inspection can be achieved. A quality

control system in manufacturing allows close communication between inspectors and production personnel. (11) Close communication results in better understanding of the desired outcome. A more consistent product quality should result.

Basis of Research - Need For a Written Quality Control Plan

Figure 1.2 illustrates the influences on quality by the consumer, site builder, and manufacturer. The term quality in residential construction can have various meanings. To the consumer, it is the aesthetic appeal, style, brand names of materials or products used, and cost. To the site builder, it is strength or grade of materials used, and the construction practices employed that exceed minimum required standards. To the manufacturer, quality is a matter of consistency in producing a product that adheres to these standards and appeals to the consumer.

The manufacturer must rely on a set of materials and standards that will satisfy both buyer and the code agency on a continual basis. It cannot vary construction practices, brands, or types of materials with each unit produced and still maintain the proper consistency.

The manufacturer must define quality in terms of consistent conformance with a set of specifications for all assembly-controllable items. These items are all of those that take place on the production floor and are subject to inspection by quality control

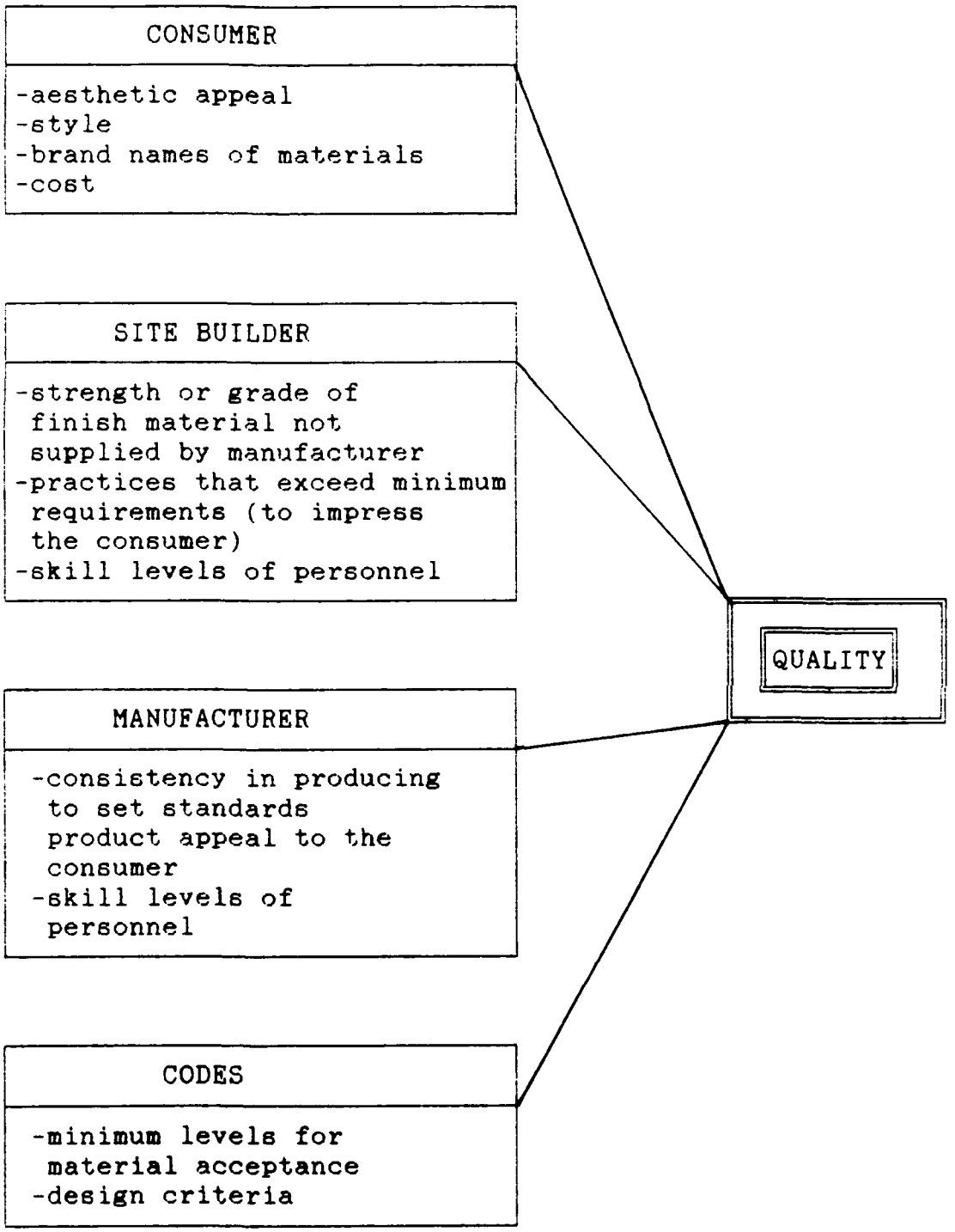


FIGURE 1.2

Influences on Quality in the Modular Process

personnel. The subject of this report is confined to the analysis of these assembly-controllable items.

Penn Lyon Homes, Inc., a central Pennsylvania manufacturer that operates three manufacturing plants, is the firm studied for this report. Each plant currently constructs home modules at a peak rate of 4 to 5 per day. Units are typically 95% complete. To achieve quality, workmanship at the factory must be closely monitored. While a sophisticated quality control program is not used by the representative firm, a rudimentary program does exist. However, it is not properly utilized, there are too few quality control personnel, and they are not adequately trained. Skills of inspection and documentation of the detailed work items are learned through trial and error.

The quality control documents used for each unit are not commensurate with the quality control standards indicative of modern manufacturing facilities. Cosmetically, most work meets required quality standards, but no consistent documentation is available to verify quality control.

A well written, functional quality control program is essential for a manufacturer to produce a consistent level of quality. (11) Specifically, quality control must ensure that each module is constructed without major defect. The program should document workmanship mistakes, engineering errors, material deficiencies, rework, and similar data, to ensure that a manufacturer can implement corrective measures. With the collected data, inspection

frequencies, areas of inspection emphasis, crew sizes, engineering effort, and material types and usage, can be evaluated. Long-run benefits will outweigh short-run implementation costs. (12)

Objective of this Report

Modular manufacturers are required by law in most states to have a quality control program. However, these are really code compliance programs. Code authorities and inspection agencies have no jurisdiction outside of code requirements. The manufacturer controls most of the quality opportunities for the consumer. In-plant inspectors check both cosmetic quality and code compliance. However, the system has not been refined to the point that the information generated is of any immediate value. (12)

Inspection guidelines should provide more than just code compliance and cosmetic quality information. Detailed assembly requirements for each module should be provided along with a document to monitor each phase of production. (11,13) Resources can be optimized, errors can be corrected in a timely manner, and management can be provided a summary of quality conformance for each unit.

The objective of this project is to develop an integrated quality control program. The individual production areas that require quality control and the degree of control necessary will be evaluated. A sample set of documents for a work area will be

developed. An implementation strategy and staffing plan will also be discussed.

Methodology of the Study

This study was accomplished in four parts: 1) a literature review, 2) a review of the manufacturer's current quality control documents, 3) in-plant quality control data collection, and 4) data analysis.

The literature review covered quality control in both general manufacturing and the specific area of modular housing. General manufacturing was researched to gain basic quality control concepts. Modular housing was researched to determine the current state of the industry as well as trends in quality control improvement. Very little specific information, outside of general quality concerns, was found in the area of modular housing. The modular industry has provided no specific quality control program information. The majority of the literature found was in periodical form. The articles were written for the popular audience with little quality control discussion. Where quality was addressed, it was a by-product of the ongoing code debate and the manufacturers difficulties in marketing its product within the various states. Therefore, the literature review yielded nothing more than background information.

The manufacturer's current quality control documents, considered representative of the industry, were reviewed to determine the state of the quality control program currently in use. There were two

documents: the Quality Assurance Manual and the Product Manual. (16,21) For each, the structure, organization, and overall usefulness to product quality control were evaluated.

Data collection was accomplished through the acquisition of 235 completed quality control inspection forms, 30 hours observation of in-plant production, and a series of meetings and conversations with quality control, production, and engineering personnel. Data collection yielded a data package comprised of 1575 recorded quality deficiencies, a working knowledge of modular housing assembly, and a series of comments from key personnel.

Data analysis was then performed. From the recorded inspection information, statistical data about the types and numbers of quality deficiencies were compiled. The effectiveness of inspection efforts was also evaluated. The quality assurance and product manuals revealed program strengths and weaknesses. Combining the analyses made from the statistical data and the program strengths and weaknesses, a framework for recommended program revisions established.

Organization of this Report

The first chapter has briefly described the modular home manufacturing industry and the importance of quality control. It also described the objectives, methodology and organization of the report.

Chapter 2 presents a manufacturing plant layout, definitions of quality control terms, and a brief overview of the purpose and application of a quality control system in a manufacturing plant. Each activity in the production process is given a "system" description and number in accordance with the flow of work in the plant.

Chapter 3 provides an in-depth evaluation of the existing quality control program used by the study manufacturer. Important quality control statistics are presented in this chapter. These form the basis for areas requiring additional development. Also discussed are the current inspection priorities, their advantages and disadvantages, and definition of the areas needing revision.

Chapter 4 provides the organization and key portions for a revised quality control program.

Chapter 5 describes the proposed implementation strategy and timetable for the revised program. Staffing and training recommendations are also provided.

Chapter 6 chapter provides some general conclusions, recommendations, and suggestions for further research.

CHAPTER 2

BACKGROUND

Manufacturing Plant Structure and Layout.

Modular manufacturers utilize the assembly line with major work stations or bays.(1) These bays represent modules in various stages of completion. Using the assembly line process, the manufacturer is capable of customizing the floor plan of each unit while maintaining standard, repetitive functions at each work station. The assembly line is not mechanized, nor is the production "high volume." In fact, in most plants workers push the units from station to station. (9) The construction sequence and building practices are simply defined and easily mastered. For this reason, the manufacturer can build a custom product with low skilled labor. Minimal formal training is provided within the manufacturing environment.

Manufacturing construction methods are similar to traditional site built houses. Some exceptions are that the walls and floors are constructed on special jigs, or templates for cutting and fitting, nailing is done with pneumatic nail guns, and sheetrock may be foam glued rather than nailed. The units are built from the inside-out, which is directly opposite the site built house built from the

outside-in. The general sequence for assembly is as follows:

The floor is constructed on a special jig which ensures accurate joist spacing, squareness and overall precision. To it, all plumbing and electrical are added if necessary. Any required linoleum is also placed at this time. Next the walls are built on special jigs at another work station. Sheetrock is glued to the inside wall face and all cut-outs are made. As the walls and floor are joined at the next station on the line, rough electrical and plumbing, are installed in the walls from the outside. To speed the process, many sub-assemblies are pre-made at a nearby location in the plant. Tubs, showers and toilets are also added. Simultaneously, the ceiling, comprised of wood joists foam sealed to the ceiling sheetrock, is lifted from its work station (usually a mezzanine) and set onto the walls. The same holds true if the roof is set on a one story except that pre-made trusses replace ceiling joists. Also during this time, all sheet rock is taped and sanded on the inside walls. Next is the application of insulation, paint, roofing & siding, doors & windows and interior trim. The last step is carpet, cabinets, minor touch-up and wrapping for shipping. Electrical and plumbing systems are final tested and the module is set onto a trailer ready for delivery. (9)

While adequate for general discussion, each manufacturer has modifications to the above sequence.

Quality Control In Manufacturing

Quality control in manufacturing takes three forms: 1) quality of design, 2) quality of conformance with specifications, and 3) quality of performance. (14,15) Quality of design relates to the materials selected for manufacture. This is often determined by cost and consumer preference. Quality of performance is controlled by codes and standards for minimally acceptable end use requirements. Quality of conformance with specifications measures the consistency of the manufacturing process itself. The specifications reflect both the design and performance quality. The level of consistency in satisfying the specifications measures the overall quality.

Conformance with specifications is the base upon which this report is constructed. This quality is controlled in three ways: 1) by defect prevention, 2) by defect detection, and 3) by defect analysis and correction. Defect prevention employs specifications, standards, and the types and frequencies of quality control inspections. Defect detection utilizes inspection methods, tests, and record keeping. Defect analysis and correction relates to trend analysis and implementation of new methods in the production process. (15)

To summarize, quality control is defined as a system for verification and maintenance of a desired level of quality in a product or process by careful planning, the use of proper equipment, inspection, and corrective action where required. (15) It is the

method of assuring compliance with existing standards. A satisfactory product meets an agreed set of requirements that are based on a defined outcome. This is the basis of a quality control program. If everyone clearly understands what is expected, quality products can be produced consistently.

Therefore, a quality control program is a written set of procedures and policies, with fixed requirements to assure the desired outcome is monitored and controlled. Proper control results in minimum variability in the outcome of the product. (15)

Key Terms in the Modular Manufacturing Process

A system, is a consistent, well defined task that takes place at approximately the same location each time it is performed. A system is not the same as a work station or bay described earlier. Several systems may be employed at one work station. Work stations or bays are physical divisions of the assembly line used to describe the flow of work in the plant. Systems refer to the specific work performed. Examples are: floor framing, roof shingle application, rough electrical wiring, and siding. Table 2.1 lists the 26 total systems identified in a modern modular plant, and figure 2.1 illustrates a typical plant layout and the order in which the systems are arranged. A system stands alone as an independent, identifiable task that has a crew of workers assigned to it. For example, floor framing is a system performed by a dedicated crew, and, regardless of

TABLE 2.1

26 Building Systems In a Typical Modular Plant

SYSTEM NUMBER	SYSTEMS NAME	DESCRIPTION
1	FLOOR FRAME	FRAME, DECK, AND VINYL FLOORING
2	MILL SHOP	PRE-CUT FRAME OPENINGS FOR FLOORS AND WALLS
3A	END & INT. WALL FRAME	SHORT WALLS, 12'-6" MAX. WITH DRYWALL
3B	SIDEWALL FRAME	LONG WALLS 66' MAX., WITH DRYWALL
3C	WINDOW FRAME SHOP	WINDOW FRAME ASSEMBLY
4	WALL SETTING ON FLOOR	ATTACH WALLS TO FLOOR FRAME
5A	ROUGH PLUMBING	PIPE IN WALLS/FLOORS TUBS AND TOILETS
5B	CEILING PLUMBING	PIPE AND DUCT IN CEILING
5C	FINISH PLUMBING	HARDWARE AND TEST
6	DRYWALL TAPING	TAPE AND FILL ALL VOIDS
7A	ROOF FRAME	CEILING/ROOF TRUSS ASSEMBLY
7B	ROOF FRAME SET	ATTACH ROOF FRAME TO WALLS
8A	ROUGH ELECTRICAL	WIRE, BOXES, MAIN PANEL
8B	FINISH ELECTRICAL	SWITCHES, RECEPTACLES, LIGHTS AND TESTS
9A	DRYWALL SANDING	PREPARATION FOR PAINTING
9B	PAINTING	SPRAY PAINT WALLS/CEILINGS
10A	ROOF SHEATHING	OSB DECKING, OVERHANGS, AND FLIP PANELS
10B	FELT AND SHINGLES	15# FELT, ASPHALT SHINGLES
11A	EXTERIOR SHEATHING	SIDE SHEATHING, INSULATION, AND TRIM
11B	DOORS AND WINDOWS	INT. & EXT. DOORS AND WINDOWS
11C	EXTERIOR SIDING	VINYL SIDING
12A	DOOR FRAME SHOP	ASSEMBLE DOOR FRAME AND TRIM
12B	INTERIOR FINISH	TRIM AND MOLDINGS
13A	CARPETING	WALL TO WALL CARPET
13B	CABINETS	KITCHEN CABINETS, VANITIES, MIRRORS AND SINKS
13C	WRAPPING	POLY WRAP AND PREPARATION FOR SHIPPING

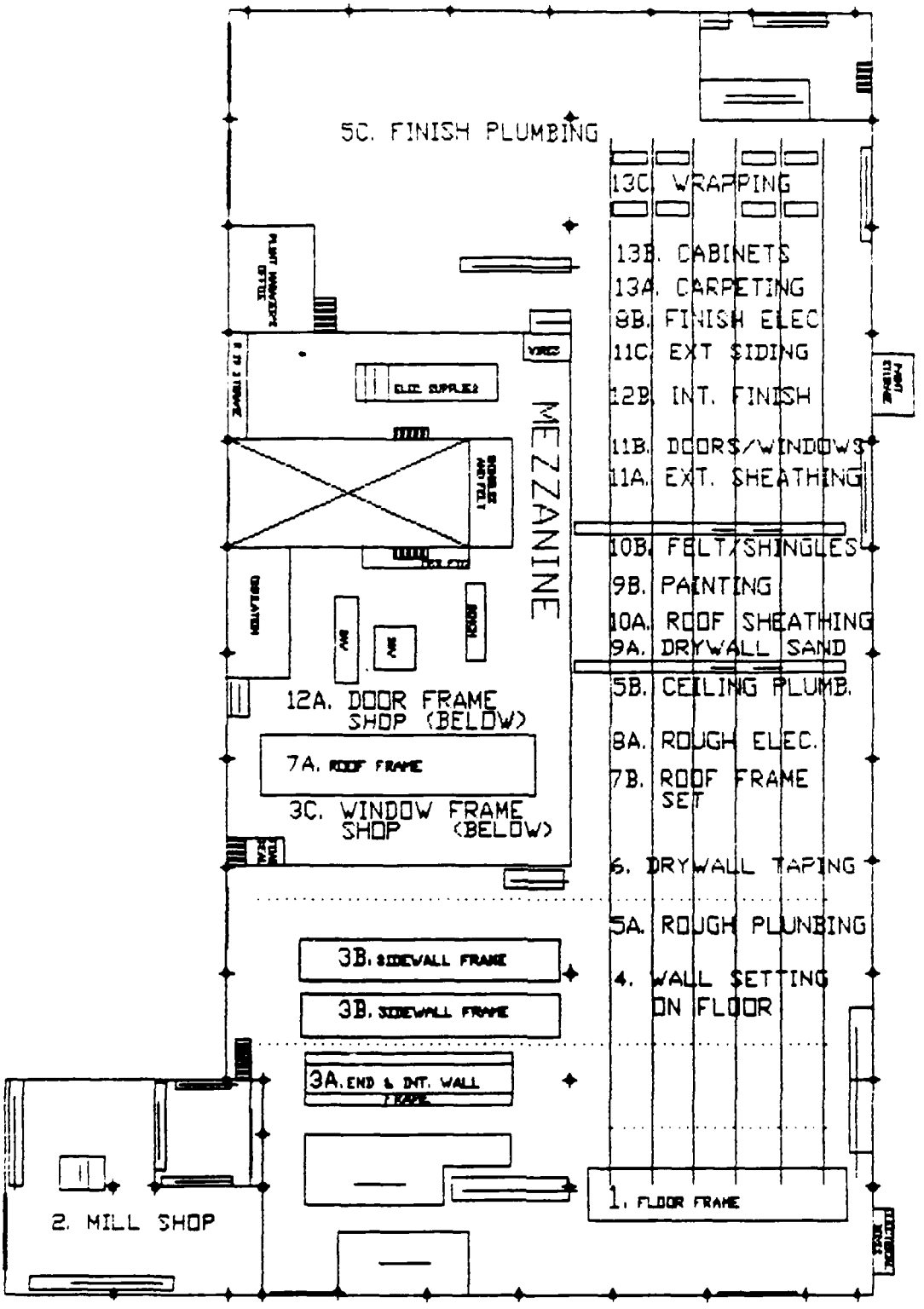


FIGURE 2.1

Typical Modular Plant Layout

size, is constructed at the same location, by the same crew. The roof frame building system will be utilized to illustrate the development of a revised quality control program.

Work items are components of a system. The floor framing component work items are joist framing, blocking, sheathing placement, and openings or cut-outs. Each work item is subject to quality control, and each system defined by standard work items.

Inspection requirements are specific procedures outlining the nature, type and frequency of inspection for each work item.

Using the system approach to describing the work, an inspection program can be implemented whereby all work is traceable to a specific module, task, location and crew. An accurate and systematic review of each module can be performed.

Quality Control Program

Given the above definitions, a quality control program should consist of: 1) a method of documenting all inspections and ordering corrective action for all noted deficiencies, 2) procedures for handling and documenting changes in the scope of work for each unit produced, 3) accurate production drawings and details, 4) defined inspection schedules and frequencies, and 5) a series of work item requirements or specifications.

Inspection documents should be simply written and easy to complete. Workmanship, rework, and design should be recorded in the inspection. Documents should be completed by trained inspectors who have the ability to write clearly and professionally.(17) Documentation that is not legible serves no purpose. Types and frequencies of inspections must be demonstrated to all production workers. They should be able to self-check work prior to inspection. All work must be documented, whether it is performed correctly or incorrectly. This ensures 100% performance and inspection of all work. When work is found to be deficient, it must be documented in a manner that describes the non-conformance and describe corrective action. This is critical if additional material or labor is required for rework, or if a design deficiency is causing a quality problem. Rework often affects the production rhythm in several adjacent building systems. This information must be part of the production history of each unit. The work item specifications must be written so that all production personnel understand their content. Specifications must coordinate closely with all production drawings and inspection requirements.(11)

All written inspection requirements should reference the applicable standard to limit in-plant disputes over requirements. This cross reference system also ensures credibility of the quality control program for third party inspection agencies.

Finally, the quality control program must be flexible towards revision of requirements. Production workers and quality control

personnel should provide meaningful input into the program if deficiencies in the inspection, work practices or design of the units require changes. Through participation, they gain a sense of contribution to product quality.

Manufacturing Plant Organization

Figure 2.2 illustrates a typical modular manufacturing organization. The major components are sales, engineering, production, quality control, and financial control/purchasing. The titles of the components may vary, but the responsibility functions are the same. (18) Proper implementation of a quality control program will require that a clear definition of the chain of command and flow of information throughout the organization be provided.

State Codes

To sell products interstate, the manufacturer must comply with various state building codes that are amended versions of the various BOCA codes. Units are often built to the most strict state code so that standardization of in-plant practices can be maximized. Table 2.2 indicates, for nine states, the various codes and amendments to which the units must comply. Overall, New York State variations contain the strictest amendments to the basic

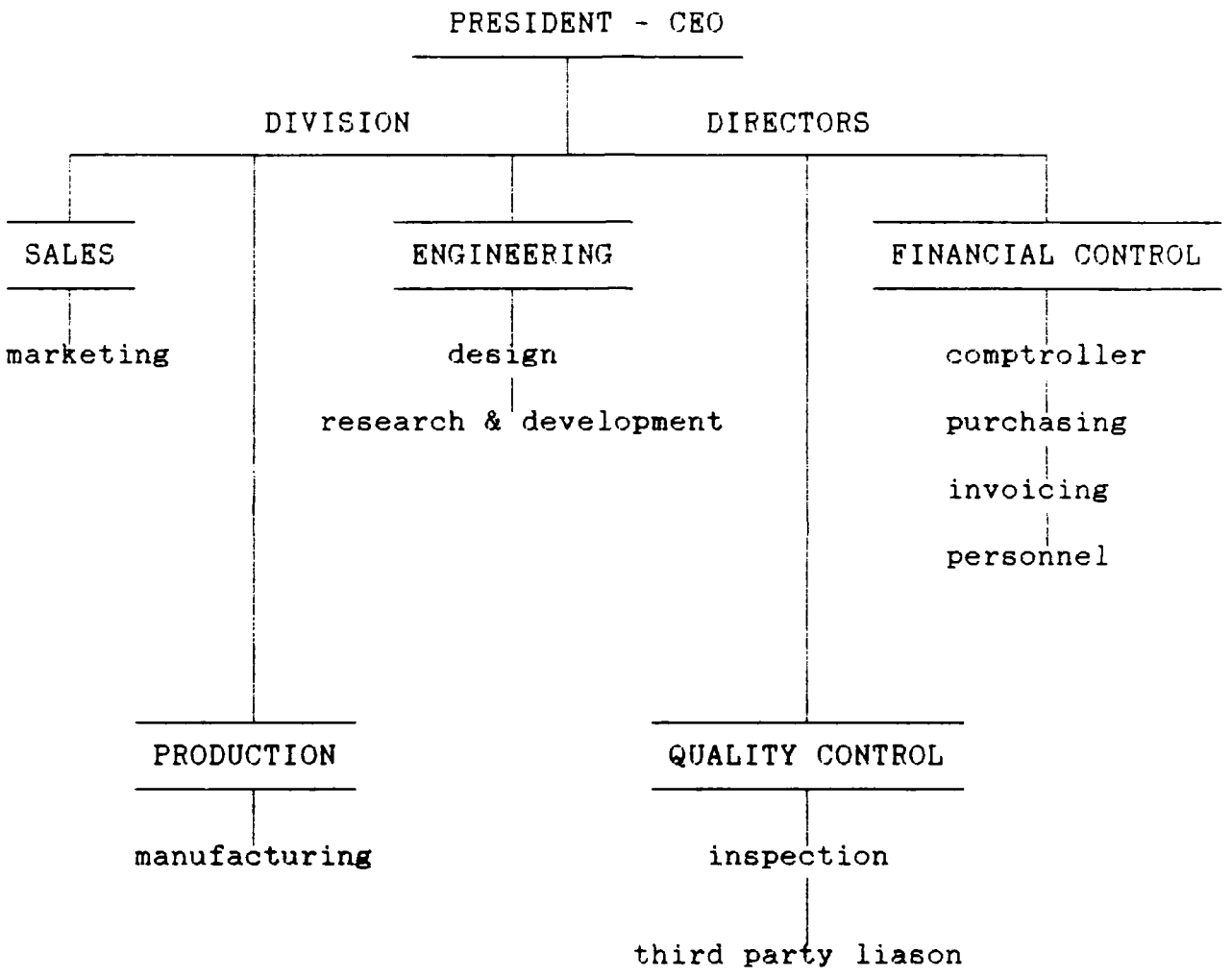


Figure 2.2

Typical Modular Manufacturing Organization (18)

TABLE 2.2

Applicable Codes and Amendments (16)

VIRGINIA
- 1987 BOCA National Building Code
- 1987 BOCA National Plumbing Code
- 1987 BOCA National Mechanical Code
- 1987 National Electric Code
- ASHRAE 90-75

MASSACHUSETTS
- 1984 State Building Code w/Amendments
- 1984 State Plumbing Code
- 1987 National Electric Code
- 1988 State Energy Code

MAINE
- 1987 BOCA National Building Code
- Maine State Plumbing Code w/86 Revisions
- 1987 National Electric Code
- NFPA Standard #31 (Mechanical 87 EDT)
- 1987 BOCA National Energy Conservation Code

RHODE ISLAND
- 1986 CABO 1 & 2 Family Dwelling Code
- 1987 BOCA National Plumbing Code
- 1987 BOCA National Mechanical Code
- 1987 National Electric Code
  (All with RI Amendments)

CONNECTICUT
- 1987 CT Basic Building Code Supplement
- 1984 BOCA Basic Building Code
- 1985-86 BOCA Supplement
- 1984 BOCA Basic Mechanical Code
- 1984 BOCA Basic Plumbing Code
- 1986 CABO 1 & 2 Family Dwelling Code
- 1985 NFPA 101
- 1987 National Electrical Code
- 1986 ANSI Standards (Barrier Free Access)
- 1984 BOCA Energy Code with 1987 CT Supplement

MARYLAND, DELAWARE, NEW HAMPSHIRE, VERMONT & WEST VIRGINIA
- 1987 BOCA National Building Code
- 1987 BOCA National Plumbing Code
- 1987 BOCA National Mechanical Code
- 1987 National Electric Code
- 1987 BOCA National Energy Conservation Code

NEW JERSEY
- 1987 BOCA National Building Code & N.J.A.C. Supplement
- 1986 National Standard Plumbing Code & N.J.A.C. Supplement
- Fire Protection Subcode per N.J.A.C.
  (Portions of the Building Code and the NEC)
- 1987 BOCA National Mechanical Code per N.J.A.C.
- Barrier Free Design Regulations/Title 17 N.J.A.C.
- 1987 BOCA National Energy Conservation Code with N.J.A.C. Supplement

NEW YORK
- 1987 NY Energy Conservation Construction Code
- 1986 NY Uniform Fire Prevention and Building Code
- 1984 National Electric Code

PENNSYLVANIA
- 1987 BOCA National Building Code
- 1987 BOCA National Plumbing Code
- 1987 BOCA National Mechanical Code
- 1987 National Electric Code
- PA Energy Code - PA Bulletin #16

codes. Therefore, New York requirements control the majority of material and construction standards. (19)

Inspection by Outside Agencies

Since the modular house arrives at the site closed in, local building code enforcement officials cannot inspect various stages of construction as they would in a site-built home. (1) Therefore, to protect the consumer, the law requires that each manufacturer be reviewed and approved for both design and inspection. This is accomplished by government inspectors or independently contracted third party inspectors. Third party agencies are approved independently by each state that the manufacturer serves. Pennsylvania uses the third party model of inspection.

Submission of a quality assurance plan is one of the basic requirements placed on the manufacturer. This plan must specifically describe the quality control organization, personnel qualifications, and methods for quality assurance. It must also demonstrate that all design, construction and in-house inspection complies with applicable codes and administrative requirements. The third party agency is responsible for approving this plan and inspecting a percentage of all modules built. Quality control practices are also reviewed during visits to the plant.

Synopsis

While a great deal of preparation for a quality control program is required, the benefit will be improvements in product quality. Legislative and third party agencies are not sufficient to ensure quality. The manufacturer selects materials and employs the production team. Therefore, the manufacturer must have sufficient means to control these resources to ensure the highest consistent quality.

CHAPTER 3

ANALYSIS OF A PENNSYLVANIA MANUFACTURER'S QUALITY CONTROL PROGRAM

Overview

The existing program, used by the study manufacturer, was examined to determine deficiencies and areas requiring improvement. The existing program addresses quality assurance in 3 forms: 1) a quality assurance manual which outlines company philosophy, organization and planned quality control practices, 2) a product manual which provides somewhat detailed specifications for module construction and, 3) in-plant quality control inspection forms used to document deficiencies in the construction of each module.

The quality assurance and product manuals are basically management documents and have not been used in the plant by either production or quality control personnel.

Quality Assurance Manual

The manual outlines the requirements, objectives, procedures, and staffing necessary to maintain product conformance within the guidelines of the states the manufacturer serves. It is reviewed and

approved by each state, and third party inspection agency, who must oversee the entire quality control program from design to construction. Table 3.1 is the table of contents for this document.

The strengths of this manual are:

1) The manufacturer's organizational structure is well defined.
2) There is clear delineation of key personnel assignments and responsibilities.

The weaknesses are:

1) Detailed 'quality control inspection forms,' illustrated by figure 3.1, have no instructions for use. They are completed by the foremen, with only an after the fact verification by the inspectors. This is an effective tool for monitoring work completion, but not for quality control.
2) A one page generalization of inspection procedures is given in figure 3.2. There is no coordination between the individual work items and the type or frequency of inspection required. The 'quality control inspection form,' is not referenced as part of the procedure.
3) Instructions and procedures are confusing and disjointed. Figure 3.3 is one of three flow charts which outline problem resolution procedures for plant personnel. It is difficult to follow and not widely used by company personnel. (20)
4) The manual is disorganized. Topics, such as firestopping details, testing, and products specifications, belong in the

TABLE 3.1

Table of Contents
For Study Manufacturer's Quality Assurance Plan (16)

PAGE 7 OF 7 SERIAL NUMBER

INSPECTION ITEM	COMMENTS	APPROVE LEAD MAN	APPROVE FOR MAN	REWORK (QC)	REINSPECT (QC)
STATION 10A - FINISH ELECTRIC (CONTINUED)					
8 CHECK CONNECTIONS OF ELECTRICAL DEVICES, FIXTURES					
9. SPECIAL DETAIL DRAWINGS IN WARRANTY PACKAGE					
10. TRANSIT WRAP APPLIED PROPERLY TO PREVENT WATER DAMAGE					
11. PROPER STATE AND THIRD PARTY LABELS AND INSIGNIAS APPLIED					

Q.C. INSPECTOR _____ FOREMAN _____

INSPECTION ITEM	COMMENTS	APPROVE LEAD MAN	APPROVE FOR MAN	REWORK (QC)	REINSPECT (QC)
STATION 10B - FINISH PLUMBING					
1. D.W.V. : TYPE, SIZE					
2. WATER SUPPLY: TYPE, SIZE					
3. FITTINGS : PROPER SLOPE, TRAPS, AND VENTS					
4. PLUMBING: ALL WATER SUPPLY LINES ARE CHECKED AND DRAIN LINES TESTED (WHERE APPLICABLE)					

Q.C. INSPECTOR _____ FOREMAN _____

COMMENTS

FIGURE 3.1

Example 'Quality Control Inspection Form'
From the Study Manufacturer's Quality Assurance Plan (16)

INSPECTION PROCEDURES

ALL QUALITY CONTROL INSPECTORS WILL BE TRAINED PERSONNEL IN MANUFACTURING PROCESSES AND KNOWLEDGEABLE IN BUILDING CODES AND REGULATIONS. EACH INSPECTOR WILL BE FAMILIAR WITH PENN LYON HOMES, INC. STANDARD PRODUCT AND PRACTICES. HIS JOB WILL BE TO INSURE THAT ALL UNITS ARE BUILT IN ACCORDANCE WITH THE THIRD PARTY APPROVED PLANS AND SPECIFICATIONS, AS WELL AS CHECK TO INSURE THE WORKMANSHIP IS OF THE COMPANY'S EXPECTED HIGH QUALITY.

EACH SALES ORDER WILL BEAR A JOB NUMBER WHICH EACH INSPECTOR WILL IDENTIFY ON HIS INSPECTION FORM. THE INSPECTION FORM WILL INDICATE THIS NUMBER FOR RECORD KEEPING PROCEDURES AND WILL BECOME PART OF THE JOB FILE.

EACH FORM WILL INDICATE THE PRE-DETERMINED POINTS OF INSPECTION ALONG THE PRODUCTION LINE. THE INSPECTOR AND FOREMAN ARE TO PERFORM AN INSPECTION PERSONNALLY, WHETHER IT BE VISUAL, DIMENSIONAL, STRENGTH, SQUARENESS, ETC. THE INSPECTION FORM WILL INDICATE WHETHER THE FUNCTION HAS BEEN PERFORMED IN CONFORMANCE WITH APPROVED STANDARDS.

THE INSPECTION FORM WILL BE COMPLETED ON EACH UNIT AND SENT TO SALES FOR RECORD. ALL SUMMARY SHEETS WILL BE REVIEWED FOR REOCCURING DEFECTS OR POTENTIAL EFFICIENCY REPORTS FOR FURTHER CONSIDERATION.

FIGURE 3.2

Inspection Procedures
From the Study Manufacture's Quality Assurance Plan (16)

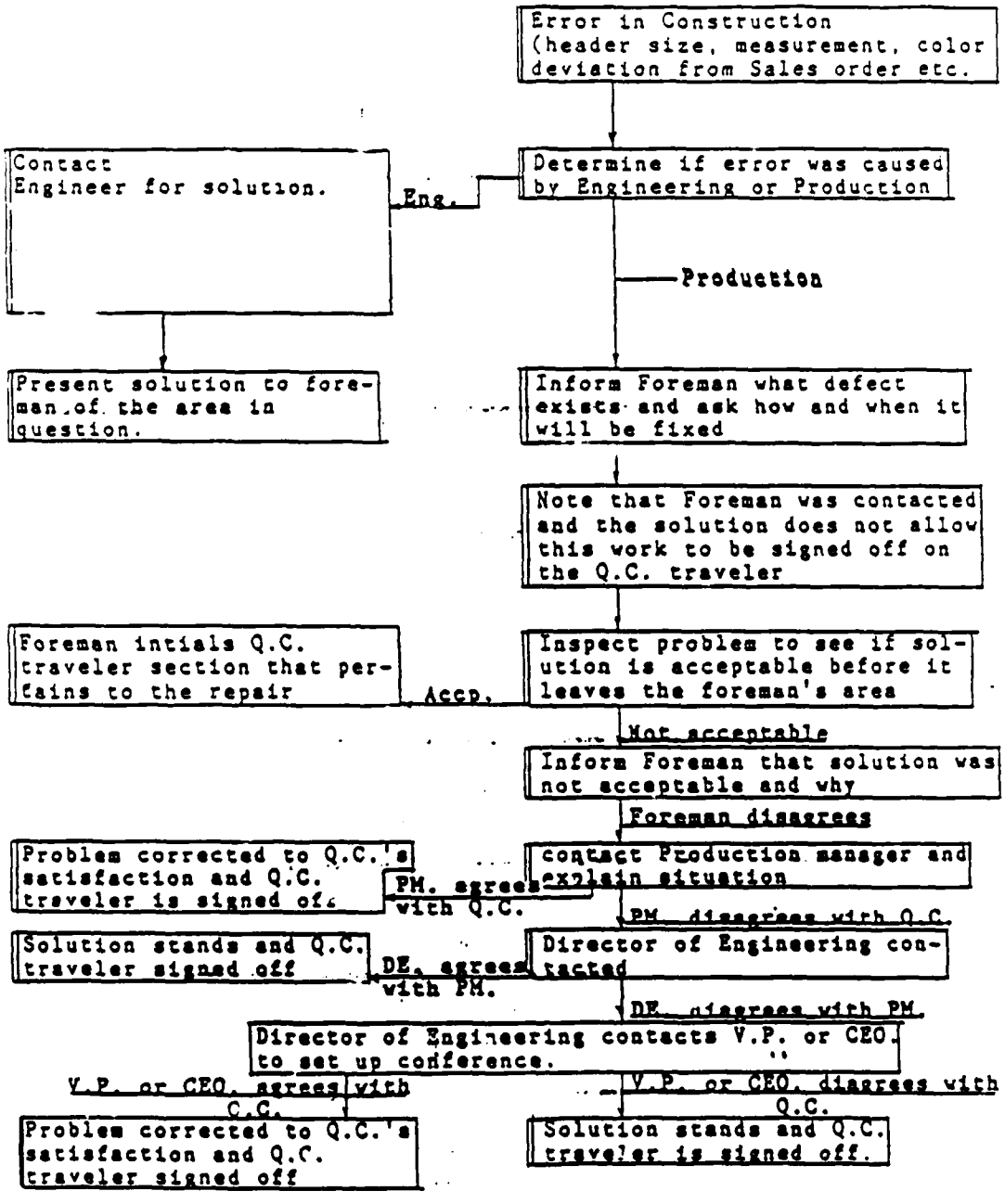


FIGURE 3.3

Example Flow Chart for Problem Resolution In-Plant
From Study Manufacturer's Quality Assurance Plan (16)

product manual.

5) The topics are not fully related in sequence. General administrative chapters are separated by chapters on specific construction details. For example, New Jersey labeling procedures is Chapter III, and New Jersey record keeping is Chapter XXVII. While many topics are needed to satisfy all the varying state requirements, they should be better organized.

Product Manual

The product manual is a production guideline. It contains specifications and procedures pages for 18 construction entities. There is no table of contents for this document, but a listing of the 18 construction entities is provided as table 3.2

The strengths of the document are:

1) It is an effort to provide a production document that describes the construction details of a modular home.
2) While the specifications and procedures are very detailed, they are easily understood.
3) The document is standardized for all construction. It does not require revision of content for each unit designed.

The weaknesses are:

1) The document's introduction indicates that an inspection page accompanies each specification and procedures page. This is

TABLE 3.2

Listing of 18 Construction Entities
Described in Study Manufacturer's Product Manual (21)

1. FLOORS
2. EXTERIOR WALLS
3. CENTER BEARING WALLS (MARRIAGE WALLS)
4. NON-BEARING INTERIOR PARTITIONS
5. CEILINGS/ROOFS
6. DRYWALL FINISH
7. DOORS
8. WINDOWS
9. EXTERIOR FINISH/COVERINGS
10. PLUMBING
11. ROOFING
12. WINDOWS/EXTERIOR DOORS
13. INTERIOR DOORS
14. ELECTRICAL
15. HVAC
16. CABINETS
17. ACCESSORIES, MOLDINGS AND TRIM
18. TRANSPORTATION/CLOSE-UP

true only for floor frame building. In other areas, inspection pages are not found.

2) The specifications and procedures pages numbering are not coordinated as seen in figure 3.4. For example, plumbing specification A-3.0, "Valves," does not correspond to procedure B-3, "Fixtures."
3) Coordination with procedural requirements in the quality assurance manual, such as testing, firestopping, and product specifications, is lacking.
4) Specifications and procedures items do not match inspection items on the 'quality control inspection forms' found in the quality assurance manual. Item numbers do not match.
5) The document is not used by production personnel. It is not referred to during construction and is not used as a training guide. (20)

Existing In-Plant Quality Control Practices

Inspection Form

Figure 3.5 illustrates the actual inspection document used in the factory. It is a simply arranged form with space allocated for inspection data, foreman contacts, corrective action, signature and date. The inspector has complete discretion with this form. There is no written procedure for completion. Inspection data can be entered in any manner with notations for several different units listed on the same page. Yet, it is the primary quality control tool and is the only inspection document used consistently.

X. Plumbing

A. Specifications: the following specifications cover the standard product line produced by Penn Lyon Homes, Inc., with regard to plumbing.

A-1.0 Supply lines- water supply lines shall be of type L copper pipe with soldered connections, sized in accordance with the applicable code. All plumbing on the first floor shall be stubbed thru the floor at each fixture for connection on site. Supply lines on the second floor of two story units will be manifolded together to a chase area, and access provided for site hook-up.

A-2.0 DWV system- DWV system shall be of schedule 40 PVC pipeand fittings, sized and installed in accordance with applicable codes. Pipes in the first floors will just be stubbed thru the floor for on site connection drain lines on the second floor will be run to a chase area, with access provided for site hook-up.

A-3.0 Valves- full flow stop valves shall be installed at all plumbing fixtures, with access provided for operation.

A-4.0 Fixtures

A-4.1 Water closet- water closets shall be viterous china close coupled fixtures with seat and cover, and shall be bone color as standard.

A-4.2 Lavatory- lavatories shall be cast cultured marble with pop up drain, overflow, and single lever faucet.

A-4.3 Bathtubs- bathtubs shall be one piece fiberglass with pop-up drain and single lever faucets. Color will be bone Tub shall be supplied with a shower curtain rod.

A-4.4 Showers- individual showers shall be one piece reinforced fiberglass with single lever faucet. Color will be bone. Shower will be provided with a curtain rod.

A-4.5 Kitchen sink- kitchen sinks shall be double bowl stainless steel with single lever faucet and spray attachments.

A-4.6 Exterior faucet- homes shall be supplied with one exterior frostproof hose bib.

A-4.7 Washer hook-up- optional washer hook-up shall be provided recessed in wall with hot and cold water hose connection and drain.

A-4.8 Water heater- homes will be supplied with a 42 gallon glass lines insulated energy efficient electric water heater, with 240 volt-4,500 watt dual non-simultaneous elements.

FIGURE 3.4

Specifications and Procedures Pages for Plumbing
One of 18 Construction Entities
Described in Study Manufacturer's Product Manual (21)

XIV. Plumbing

B. Procedure: the following procedure shall be used for plumbeimg installed in homes built by Penn Lyon Homes, Inc.

B-1 Water lines- water lines shall be type L copper with sweat fittings to all plumbing fixtures, with stop vinyl supplied at each. Water lines on the first floor shall be stuubed to below the floor. Water lines on the second floor shall be manifold together to a common drop, and then run thru a chase in the first floor. Lines for clothes washers an dishwashers shall be supplied with a air hammer column to prevent water hammer copper shall be sweated with 95/5 solder, applied to pipes which have been deburred, cleaned, and flux applied. Water lines shall be in accordance with approved drawings.

B-2 Drain lines- drain lines shall be scheduled 40 PVC lines connected with appropriate hub type fittings. Pipe shall be cut, deburred, cleaner/primer applied, then solvent cement applied into the hub cup. After pipe is inserted into hub, turn 1/4 turn to insure proper cement area. All plumbing on first floor shall be stubbed thru below the floor. All second floor plumbing shall be manifolded together as run thru a chase area on the first floor. Horizonal turns and turns from vertical to horizonal shall be thru long sweep fittings. Horizonal to vertical turns may be thru a sanitary tee. Lines shall be sized and installed in accordance with approved drawings. Vent stack shall extend above the roof 18" min.

B-3 Fixtures- fixtures shall be installed in accordance with manufacturer's installation instructions. Caulking shall be applied between the kitchen counter and the sink flange to prevent water damage to countertop. Bath vanity tops shall be caulked to the ajoining walls and top of the backsplash.

FIGURE 3.4 (continued)

INSPECTED	FOREMAN CONTACTED	ACTION TAKEN
4504A needs #2 Bored out + FL	TOLD Steve	
needs Dry wall Touch-up	not to take	
needs C.T.'s, needs Deceipt + Switch	out until	
Covers, C.T. Sink cut out too LARGE	Finished	
Double Bowl S.b. Single Bowl		
4504 B Br #3 Shelf Brace Screw loose	Steve	
B Br #2 Shelf Brace screw loose	Steve	
B needs Dry WALL TOUCH-UP + PAINT	STEVE TOLD NOT	
cleaned off of Entry Vinyl	TO TAKE OUT UNTIL	
C Bath #1 TAPE + Spackle corner by vanity	Finished CLINT	
C Bath #1 Vanity Supply line on ANGLE	STEVE	
C Br #2 Carpet smells moldy	DAVE	
C Bath #1 Tub chipped	KARL	
4505A S.A. Calls for 36" Front Door w/GLASS	ENG,	
Print shows #2 DOOR	OK order	
A Br #1 C/O Gets #10 Slider But has 48"	OK change	
Bi fold Jamb INSTALLED	DAVE	
A Br #1 DOOR JAMB chipped	DAVE	
A Used 2" STAPLES on flip over hang	Bernie	
A+B Roofs used 1"x1½" 2at. Bracing		
A Roof 3 STAPLES in VALLEYS		
B WIRED + Hole in wall for RANGE HOOD but	ENG.	
it is omit, cut WIRE, Patch Hole	AL/Bernie	
B m/w WIRES STAPLED 5'1"	Bernie	
A Entry EXT. wall BOWED OUT AT Ceiling	AL/Bernie,	
A Liv Rm m/w Deadman ½" short	AL	
B Din Rm m/w " " " "	AL	

FIGURE 3.5

Completed Quality Control Inspection Form (20)

The strengths of the form are:

1) It contains ample space for recording inspection data.
2) It indicates the foreman responsible for the work deficiency.
3) The signature of the inspector is required.

The weaknesses are:

1) It is poorly formatted; deficiency locations are not well documented.
2) The space allocated for corrective action is inadequate and never utilized.
3) There is no record of rework and reinspection.
4) There is no accurate reference to crew, work station, or timeliness of inspection.
5) There is no standard language for recording deficiencies; descriptions are vague and disorganized.
6) There is no consistent history of each module built without collecting several forms.

Types of Inspections, Frequencies and Statistics

Figure 3.5 is one of 235 completed inspection forms reviewed. Not all of the forms for the 6 month period from March to October 1988 were available. Each of the deficiencies listed on these forms has been analyzed and summarized into two tables. These were designed to provide useful information about the types and frequencies of inspections, and the nature of the deficiencies

themselves.

Table 3.3 illustrates the number of deficiencies noted per month, grouped into 5 categories:

1) work not performed but required (WN) - examples are: drywall cutouts for receptacles not made, molding not installed where required, firestopping in stud penetration not installed
2) defective workmanship (DW) - examples are: wall framing not square, drywall taping unsatisfactory, shingle staples exposed
3) engineering error (E) - examples are: stairwells do not line up on first and second floor drawings, wrong size door or window specified, incorrect receptacle specified
4) defective material (MA) - examples are: shower unit cracked, window broken, lumber warped
5) damage (by succeeding crews) to already installed work (ID) - examples are: paint on carpet, holes in finished walls, cuts in vinyl floor

This table indicates that 87% of the recorded deficiencies are work-not-performed or defective workmanship. These two types of deficiencies are most most common because they are most directly related to work performance. Engineering, defective material and damage deficiencies are likely to occur regardless of the quality of workmanship.

Because of the frequent occurrence of non-performed and

TABLE 3.3

Number of Deficiencies Noted Per Month
Grouped Into Five Categories

Results Based on Tabulation of all Noted Deficiencies from March to October 1988

NUMBER OF REPORTS	30	4	9	22	71	38	41	20		
REPORT NUMBERS	1-30	31-34	35-43	44-65	66-136	137-174	175-215	216-235		
MONTH OF REPORTS	10/88	9/88	8/88	7/88	6/88	5/88	4/88	3/88		
									TOTALS	PERCENT OF TOTAL
WORK NOT PERFORMED BUT REQUIRED (WN)	66	13	25	24	119	46	63	39	395	25
DEFECTIVE WORKMANSHIP (DW)	146	21	39	85	228	131	156	148	954	62
ENGINEERING (E)	20	0	0	3	9	10	5	4	51	3
DEFECTIVE MATERIAL (MA)	8	0	1	1	6	1	1	1	19	1
DAMAGE TO INSTALLED WORK (ID)	16	10	16	10	23	14	26	27	142	9
TOTALS	256	44	81	123	385	202	251	219	1561	100

defective workmanship deficiencies, table 3.4 is provided. This table is a breakdown, by system, of these deficiencies for three months of reports. As seen on the table, the five systems with the greatest number of deficiencies are sidewall framing, wall setting on floors, rough electrical, doors and windows, and interior finishes. This is explained by the fact that these systems contain more work items than the remaining 21 systems. Thus, a greater opportunity for error exists. A review of the inspection reports reveals that the top five occurring deficiencies included both code conformance and cosmetic or appearance related items. However, the cosmetic items were far more prevalent than the code items. According to inspection personnel, this is due to the fact that code compliance items were more significant and required immediate attention. A record of the deficiencies was rarely made because the inspector witnessed the correction. This suggests that the current inspection system does not provide management with a complete knowledge of quality deficiencies and quality control in the plant.

The five systems with the most deficiencies occur throughout the plant, indicating that quality problems are not limited to certain areas. Quality control improvement is needed plant wide.

There is no record of inspection frequency. Reports are not maintained for each day of production. This inconsistency is not acceptable.

TABLE 3.4

Number of Non-Performed or Defective Workmanship Deficiencies Noted
Grouped Into 26 Building Systems

Results Based on Tabulation of all Noted Deficiencies March to October 1988

BUILDING SYSTEM NUMBERS AND NAMES	WORK NOT PERFORMED (WN)			DEFECTIVE WORKMANSHIP (DW)				TOP FIVE RANKING
	OCT	JUN	APR	OCT	JUN	APR	TOTALS	
1 -FLOOR FRAME	1	1	0	8	11	3	24	
2 -MILL SHOP	0	0	1	0	2	2	5	
3A -END & INTERIOR WALL FRAME	3	1	1	21	12	7	45	
3B -SIDEWALL FRAME	3	8	0	13	21	13	58	3
3C -WINDOW FRAME SHOP	0	1	1	0	4	2	8	
4 -WALL SETTING ON FLOORS	23	45	7	29	34	22	160	1
5A -ROUGH PLUMBING	3	3	0	4	10	3	23	
5B -CEILING PLUMBING	1	3	0	2	1	2	9	
5C -FINISH PLUMBING	1	3	2	1	1	1	9	
6 -DRYWALL TAPING	2	11	8	8	8	9	46	
7A -ROOF FRAME	4	5	1	7	7	2	26	
7B -ROOF FRAME SET	3	1	0	1	4	3	12	
8A -ROUGH ELECTRICAL	4	9	19	6	16	13	67	2
8B -FINISH ELECTRICAL	0	6	4	1	1	3	15	
9A -DRYWALL SANDING	0	0	1	14	6	5	26	
9B -PAINTING (SPRAYED)	0	0	0	5	0	1	6	
10A -ROOF SHEATHING	2	2	1	3	3	3	14	
10B -ROOF FELT AND SHINGLES	1	0	0	5	8	3	17	
11A -EXTERIOR SHEATHING, INSULATION	2	1	0	1	1	1	6	
11B -DOORS AND WINDOWS	2	4	4	6	17	14	47	5
11C -EXTERIOR SIDING	1	0	0	2	1	2	6	
12A -DOOR FRAME SHOP	0	1	1	3	15	7	27	
12B -INTERIOR FINISH	3	4	5	4	21	13	50	4
13A -CARPETING	4	5	3	0	8	9	29	
13B -CABINETS	3	5	4	2	13	11	38	
13C -WRAPPING, PREP FOR SHIPPING	0	0	0	0	3	2	5	
TOTALS	66	119	63	146	228	156	778	

Staffir :

Currently, there are two quality control inspectors in the plant. However, this number has, on occasion, risen to three based on the management decision regarding the number of necessary inspectors. (19) The quality assurance manual states that two inspectors are to be utilized. Current staffing is based solely on an estimate of requirement. There has been no man-hour evaluation to determine optimal staffing. Past experience and convention are the determining factors.

Third Party Agency Influences

The third party agency inspects the design and construction of all units. State mandated in-plant evaluations of workmanship, production drawings, quality control practices are performed. Figure 3.6 is a copy of a form completed by a third party agency representative.

This inspection form is provided to the manufacturer's quality control inspector. The original is retained by the third party agency for their record and necessary actions. (22) Whenever any deficiency significantly violates state requirements, the third party agency must assure that the needed corrections in procedures or work practices are made. If corrections are not made on serious violations, the agency can disapprove or "red tag" the unit. A

Sheet 1 of 1

QUALITY CONTROL INSPECTION REPORT

Form A 6 84

PFS CORPORATION

RED TAG DISPOSITION	
PREVIOUSLY OUTSTANDING	0
ISSUED THIS INSPECTION	2
CLEARED THIS INSPECTION	2
CURRENTLY OUTSTANDING	0

DATE: _____ INSPECTOR: _____

TIME IN: _____ TIME OUT: _____

MANUFACTURER/LOCATION _____

Legend: S–Structural; P–Plumbing; M–Mechanical; E–Electrical; N/A–Not Applicable; O.K.–Acceptable; R/T–Red Tag (Not Acceptable); Y/C–Yellow Condition (Minor Violation–Corrected Immediately).

WORK STAT.	UNIT SERIAL NO.	SYS.	MAT'L.	WORKMANSHIP	CODE NO.	REMARKS
142	5513P	S	OK	OK		No Nom Conforming items Tour
	ADS	P	N/A	N/A		
	NY	M	OK	OK		
		E	N/A	N/A		
34	5510	S	OK	(Y1)	Sol	Fire wall Not Nailed
537	ADLHD	P	OK		Mat	Every 6" on perimeter
	MASS	M	OK	(R6)		Nail
		E	OK	OK	Sol	End wall to Sidewall
					Side	Not Nailed 12" OC - Rem/ OC No.
					QC	No QC Travelers on Unit
					Mat	
73	5490	S	OK	(Y2)	Sol	Fire wall Not Nailed 6" OC
9	ADL	P	OK	OK	Mat	Perimeter - Rem/Nailed - QC No
	MASS	M	OK	(Y3)		
		E	OK	OK	Sol	End wall to Sidewall
					Side	Not Nailed - Rem/ - QC No
					Sol	Exterior Shearwall Fasteners
					Side	Up to 10'0" - Rem/

Copies to Manufacturer, PFS Office

PFS CORPORATION 2402 DANIELS STREET, MADISON, WISCONSIN 53704

FIGURE 3.6

Completed Inspection Form
Prepared by a Third Party Inspection Agency Representative (20)

red-tag unit cannot be sold to the customer. However, consultation with the third party agency reveals that, most often, units are only temporarily 'red-tagged.' Manufacturer's are diligent in correcting these severe deficiencies.(22)

Synopsis of the Existing Program

A review and analysis of the Penn Lyon Homes, Inc. quality control program generates the following conclusions:

1) The quality assurance manual is disorganized and requires revision. It should contain only such items as organizational structure, personnel qualifications, work assignments, goals, policies, and administrative procedures. Other items should be in the product manual. The topic order should be re-arranged to progress from general to specific.

2) The product manual is incomplete and disjointed. Revised procedures and forms that are needed to relate clearly to the production drawings, specifications and procedures.

3) The 26 plant systems defined in chapter 2 should be incorporated into the product manual. The existing work station divisions are unclear.

4) Statistics generated from an analysis of the existing inspection forms indicate inconsistent inspection types and frequencies. Cosmetic deficiencies dominate the inspection data. Documentation of code related inspections is lacking. Accurate

quality control information is not being recorded on a consistent basis. Improvements are needed throughout the plant.

5) Quality control staffing and training requirements are not well defined.

6) Specific state requirements for construction should be incorporated into the manual. Third party agency inspection reports should also be included with the inspection form completed by the in-plant inspectors.

A more comprehensive quality control program that provides improved communications, inspections, and quality history is recommended.

CHAPTER 4

REVISED QUALITY CONTROL PROGRAM

This chapter presents a systematic revision of the quality control program. Through the reorganization of the existing quality assurance and product manuals, the administrative and procedural portions of the program are properly separated and better defined.

New Quality Assurance Manual

The proposed quality assurance manual shuold be a stripped-down version of the original. It should contain the goal statement, organizational structure, quality assurance philosophy, personnel qualifications, division of responsibility among various company divisions, facility layouts, third party administrative requirements, and procedures for manual revision. All other items have been removed and are now in the revised product manual. Table 4.1 is a table of contents. Appendix A contains a topical outline for further detail. This general outline can also serve as a model for other manufacturers.

TABLE 4.1

Table of Contents for Revised Quality Assurance Manual

CHAPTER	TITLE
1.	PURPOSE OF MANUAL
2.	QUALITY ASSURANCE POLICY
3.	GENERAL ORGANIZATIONAL CHART
4.	QUALITY CONTROL ORGANIZATIONAL CHART
5.	PLANT LAYOUT
6.	WORK FLOW DIAGRAM
7.	IN-PLANT ASSIGNMENTS AND RESPONSIBILITIES (KEY PERSONNEL)
8.	GENERAL RECORD KEEPING
9.	INDEPENDENT INSPECTION AGENCY GENERAL REQUIREMENTS
10.	INDIVIDUAL STATE APPROVAL DOCUMENTS AND CETIFICATIONS
11.	MATERIAL QUALITY POLICY
12.	SITE SET-UP CONTROL POLICIES
13.	TRAINING POLICIES
14.	KEY PERSONNEL RESUMES OR REQUIRED QUALIFICATIONS
15.	PROCEDURES FOR REVISION TO THE MANUAL

New Product Manual

The proposed product manual should be the key revised quality control program document. It should provide complete guidance to the in-plant personnel for construction of the units and complete documentation procedures for the inspection of the work. It can also serve as a model format for other manufacturers. Table 4.2 shows a proposed table of contents. Appendix B is a topical outline for further detail. The critical portion of this manual, Part 3 - "Production Quality Control," is the focus of this chapter. It is structured to the 26 building systems defined in chapter 2. For each of these systems, there is a complete quality control 'package' which contains the following five elements:

1) quality control inspection forms for each work item in the system
2) inspection instructions defining types and frequencies of inspections to be conducted
3) production drawings and details pertaining to each system
4) orderly performance specifications and work procedures
5) specific requirements

An explanation of each of the above elements is presented below. System 7A, "Roof Frame Building," is the example system used to illustrate the structure and use of each of the 26 proposed quality control packages.

TABLE 4.2

Table of Contents for Revised Product Manual

Inspection Forms

Figure 4.1 is the revised inspection form. When completed, it contains all information required to document the quality of a unit. There is a separate inspection form for each system and each module built. The procedure for properly completing this form is as follows:

1) The system foremen shall be responsible for keeping the forms in a safe location near the module and available to the inspectors at all times. The inspector shall constantly review their group of systems to ensure timely inspection of all work items. Inspectors shall complete items 2, 3, 4, 5, 8, 9, 10, 11, and 13 as required. Item 9 deficiencies should be written in a clear and concise manner. Item 10 codes should correspond to one of the five categories of deficiencies outline in Table 3.3 (WN, DW, E, MA, or ID). This will allow future categorization of all deficiencies in a data base. Item 11 should also be completed accurately and concisely. Rework is the result of the deficiencies and must be accurately measured. The foremen shall complete item 12, rework hours, when required. They are the best judge of the time required to make corrections to the work.

2) When all inspection requirements have been completed, and work is satisfactory, the inspector should sign at the bottom of the form at item 14. The module should not proceed to the next system until the inspection is finalized.

QUALITY CONTROL INSPECTION FORM

1. SYSTEM NUMBER _____ 2. UNIT NUMBER_____ 3. INSPECTOR_____ 4. FOREMAN _____ 5. DATE ____
6. DESCRIPTION _____

7.	REQUIREMENT	8.	Y/N OK	9. LOC. & DEFICIENCY	10. CODE	11. CORRECTIVE ACTION	REWORK HOURS	REWORK APPROVAL
A1	#2 lumber all locations						12.	13.
A11	spacing 16" or 24" oc							
A23	4 nails frame corners							
A23	3 nails joists/truss							
A17	OSB 2" staples 12"oc							
A1	square, no warps/cups							
A23	addl framing per drawings							
A32	chrds/jsts flush w/drywa							
A31	drywall seams ll to chords							
A32	foamseal per procedures							
A22	truss hangers set per pro.							
A15	hinges/gussets OK							
A23	splices nailed per proced.							
1612	ridge cap seat nailed OK							
A16	framing straight-no bends							

14. INSPECTOR SIGNATURE _____ 15. PLANT MGR. INITIAL _____

FIGURE 4.1

Revised Inspection Form for Roof Frame Building

3) Once signed, it shall be attached to the other unit inspection forms to maintain a complete record of inspection.

4) After the last inspection, all forms are to be removed from the unit and submitted to the plant manager for review and final release. The plant manager shall initial each form at item 15.

5) The plant manager retains the forms for submission to the quality control director for final processing.

Figure 4.2 illustrates the process described above for completing the inspection form.

Change Order Logs

Like the inspection form, the change order log provides a complete history of all change order work on a module. Figure 4.3 illustrates. It shall be completed in the same manner as the inspection form except that the foremen shall also sign, verifying awareness of the change work.

Production Drawings

Each production drawing that is created should contain a legend specifying the applicable system numbers and any work item requirements that should be noticed by the foremen and quality control inspectors. With these annotations, inspectors can make notes on the drawings that relate to item numbers on the rest

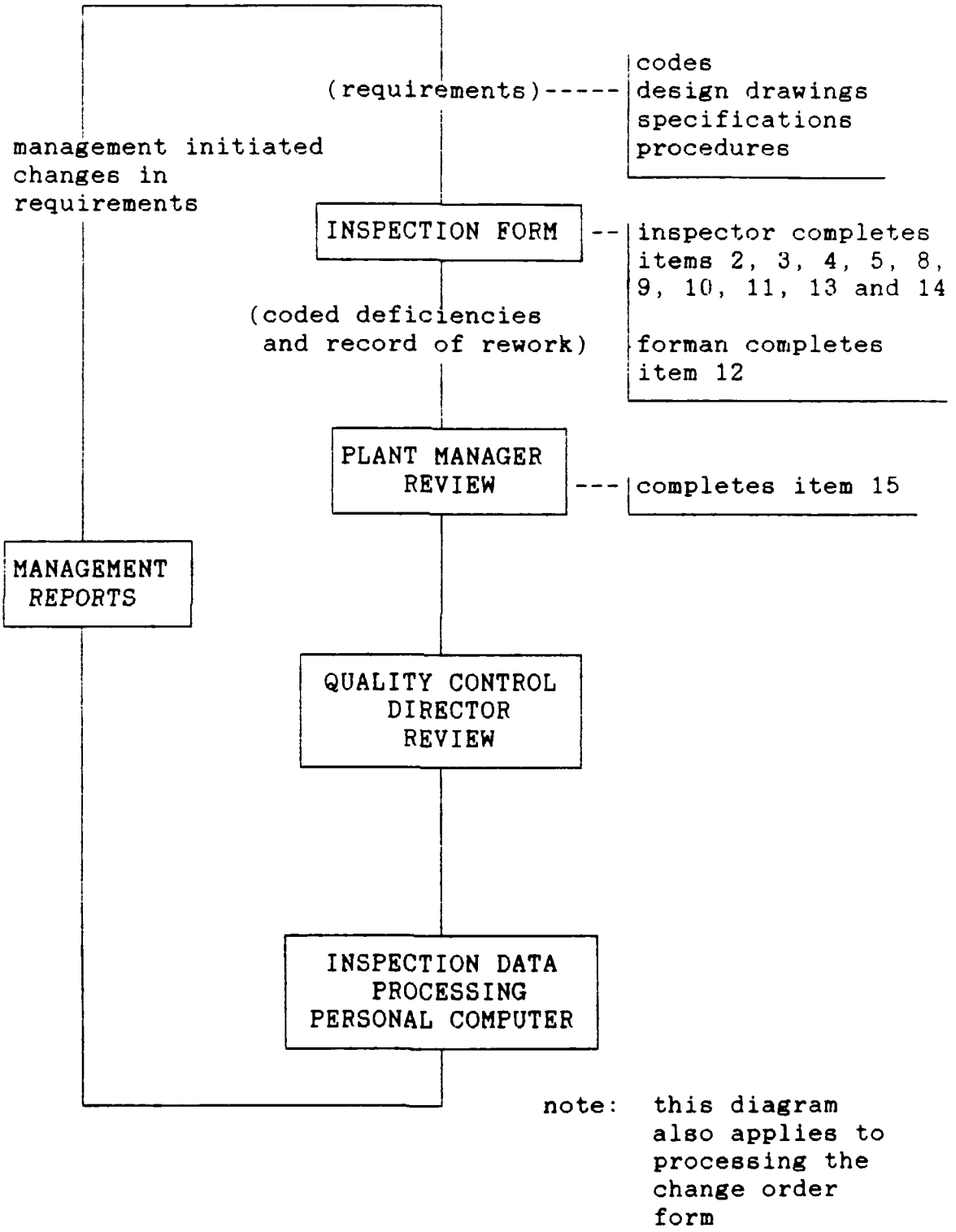


FIGURE 4.2

Inspection Form Completion Process

CHANGE ORDER LOG (after start of production)

1. SYSTEM NUMBER____ 2. UNIT NUMBER_____ 3. INSPECTOR_____ 4. FOREMAN_____5. DATE ____
6. SYSTEM DESCRIPTION _____ 7. CHANGE ORDER NUMBER _____

8. SCOPE CHANGE	HRS	Y/N	11. LOCATION & DEFICIENCY	CODE	13. CORRECTIVE ACTION	HRS	OK
	9.	10.		12.		14.	15.

16. INSPECTOR SIGNATURE _____ 17. FOREMAN SIGNATURE _____
16. PLANT MGR INITIAL _____

FIGURE 4.3

Change Order Log
Used With Revised Product Manual

of the documents in the system package. Inspectors and foremen, as part of the quality control routine should make copious notes on the production drawings. Once work is completed on the unit, the drawings should be processed with the inspection forms and marked "AS-BUILT, QC APPROVED." Appendix C contains a series of typical production drawings for roof frame building. Work item numbers are shown where applicable.

Inspection Requirements

These are instructional guides that explain the nature, type and frequency of each inspection item on the inspection form. Table 4.3 lists the inspection requirements for roof frame building. The requirements are standard and do not vary from module to module. Therefore, the inspectors and foremen need only keep one master copy available for reference. There are similar, yet distinct inspection requirements for each of the 26 systems.

Specifications and Procedures

Specifications and procedures form the original product manual were retained where accurate. However, they are reorganized and re-numbered according to the new system format. Also, the numbering of each work item now matches the inspection requirements page and form. The specifications and procedures, like the inspection

TABLE 4.3

Roof Frame Building Inspection Requirements

ROOF FRAME BUILDING SYSTEM 7A

7A INSPECTION REQUIREMENTS- 7A AND 7AB-ONE AND TWO STORY HOMES

Ensure-

7A1-#2 lumber all locations
7A11-spacing 16" or 24" o.c. for trusses or joists as specified
7A23-4 nails equally spaced for all frame corners
7A23-3 nails equally spaced for all joist or truss connections
7A23-rail nailing 3 nails vertical, 3" o.c.
7A17-1/2" OSB strip placed where required-2" staples 12" o.c.
7A1-framing square at corners, lumber not badly warped or cupped
7A23-all additional framing set per drawings and fastened 3 nails for 2x6 and 4 nails for 2x12
7A32-chords and joists flush with drywall
7A31-drywall parallel to truss chords or joists
7A32-drywall foamsealed per procedures; check bead width and length
7A22-truss hangers set at all bottom chords; 3 nails per side
7A15-all hinges and gusset plates fastened correctly and located properly-no damage
7A23-all truss or rafter splices 3 nails vertical, 3" o.c.
7A1612-ridge cap seat (2x2) centered on ridge rail-1 nail 3" o.c.
7A16-all perimeter framing straight-no bends or bulges

requirements, are standard for all modules. Only a single master copy need be retained by the inspectors and foremen. They are not issued with the production of each module. Table 4.4 illustrates the specifications and procedures for roof frame building.

Specific Requirements

What shall be issued with each module, along with inspection forms and production drawings, are specific requirements. These include specific state code requirements, non-standard building details, specifications, procedures, or inspection instructions. Examples of specific requirements for roof frame building would include such items as bolted rafter framing and special gusset plate nailing requirements. Also included would be special details and sections for infrequently constructed roofing shapes such as capes and dormers. The possibilities for specific requirements are numerous. The remaining portions of the new product manual are listed and described in Appendix B.

TABLE 4.4

Roof Frame Building Specifications and Procedures

ROOF FRAME BUILDING SYSTEM 7A

7A. SPECIFICATIONS- SINGLE STORY HOMES

7A1 Framing-

7A11-hinged trusses 16" or 24" o.c. as specified on production drawings

7A12-trusses have 10" overhang

7A13-overhang fixed on 24' wide homes

7A131-overhang on greater than 24' wide home shall be attached and is pre-manufactured

7A14-trusses shall have pitch indicated on drawings

7A15-trusses are pre-manufactured

7A16-truss framing

7A161-high end of truss-ridge rail

7A1611-upper edge of truss is 2x6 #2 spff fastened to end of top truss chord-4 nails per splice

7A1612-2x2 #2 spff attached to center of 2x6 at end of top chord of truss

7A1613-lower edge of truss is 2x8 #2 spff fastened to end of bottom chord

7A162-high end of truss-heel rail

7A1621-ends of overhang 2x6 #2 spff fastened to heel extension of truss

7A17-bearing strip

7A171-under entire perimeter and all other bearing wall locations, 1/2" wide by 7/16" thick OSB strip for bearing transfer to walls below

7A18-gable end

7A181-2x6 #2 spff box framing attached to end truss top chord-single nail 3" o.c.

7A19-knee walls

7A191-pre-cut 2x4 #2 spff verticals

7A192-top rail 2x4, 3 nails per vertical

7A193-knee walls not fastened to trusses-set in place only

TABLE 4.4 (continued)

7A2. Nails and Truss Hangers-
- 7A21-nails 1 3/4" x 0.131" power driven
- 7A22-truss hangers galvanized steel, 3 nails each side hand nailed
- 7A23-nail spacing as above and per procedures

7A3. Ceiling Board-
- 7A31-1/2" gypsum drywall place parallel to truss chords
- 7A32-glued each side of each cord with bead of 'foamseal' 200

7A4. Cutouts and Other Framing-
- 7A41-skylights and accesses
  - 7A411-framing sizes to match truss member sizes, #2 spff

7AB. TWO STORY HOMES (FIRST FLOOR CEILING)

7AB1. Framing-
- 7AB11-joists 2x6 #2 spff 16" o.c.-nailed from rails, not hung with joist hangers
- 7AB12-rails 2x12 #2 spff double around perimeter
  - 7AB121-3 marriage wall rail members (2x12, 2x12, 2x4) 3 nails, 3" o.c.
  - 7AB122-3 outside wall rails (2x12, 2x6, 2x4) 3 nails, 3" o.c.
- 7AB13-rails to be microlam over openings exceeding 16' or as specified on drawings

7AB2. Nails-
- 7AB21-1 3/4" x 0.131" power driven

7AB3. Ceiling Board-
- 7AB31-1/2" gypsum applied the same as for single story house

7AB4. Cutouts and Other Framing
- 7AB41-framing per drawings 2x6 #2 spff to match joists 2x12 for stairs-4 nails per connection

TABLE 4.4 (continued)

ROOF FRAME BUILDING SYSTEM 7A

7A. PROCEDURES- SINGLE STORY HOMES

7A31-set drywall face down on jig with seams parallel to direction of trusses
7A161, 7A162-construct roof perimeter frame-rail sizes as specified using 2x6, 2x8, and 2x12; fasten with specified nails using 4 equally spaced at each perimeter connection
7A16-check square of all framing
7A22-set truss hangers after leadman marks rails for locations
7A411-set any additional framing such as skylights and accesses per drawings
7A11-set trusses at 24" or 16" o.c. as specified, check square and spacing, and attach to rails using specified nails, 3 each equally spaced at each rail to truss connection
7A411-attach additional framing to trusses using specified nails 3 vertically, 3" o.c.
7A19-set kneewalls - do not fasten
7A17-set 10" wide by 16" or 24" OSB nailer at inside perimeter rail between each truss
7A32-ensure all drywall is flush with framing prior to foamsealing
7A32-attach drywall to truss using foamseal; 1" bead full length of chord over drywall seams. all other bottom chords, 1" bead 1/2 length of one side of chord and 1/2 of length of other side of chord; 6" overlap at middle
7A32-for all trusses 24" o.c., foamseal both sides all bottom chords
7A24-attach chain lift brackets both sides of rail, each side of roof, every 15´ of frame
7A17-after lifting roof with overhead crane, attach OSB bearing strip to bottom of outer perimeter rail with 2" staples, 12" o.c.

TABLE 4.4 (continued)

ROOF FRAME BUILDING SYSTEM 7A

7AB. PROCEDURES- TWO STORY HOME (FIRST FLOOR CEILING)

7AB11-same procedure as for single story home except trusses are replaced with 2x6 #2 spff
7AB21-all nailing and gluing as per single story specifications
7AB12-see specifications for required perimeter rail members

CHAPTER 5

IMPLEMENTATION STRATEGY

Introduction

An implementation strategy introduces change to an existing program in a way that minimizes the adverse affects on the flow of work. It should provide estimates for the time to complete the transition, recommend training and staffing requirements, and provide a mechanism for the user to adjust the program to meet its needs.

This chapter presents a plan whereby several of the systems are identified for a pilot program. The pilot program requires a trial operation period followed by an evaluation period. During the trial operation period, the program operation is documented. The evaluation period should provide feedback for possible system revisions. After satisfactory application in the trial system, remaining systems should be implemented incrementally.

This chapter outlines an implementation plan. Specific development of the implementation plan remains to be accomplished by

the user. However, a means for a manufacturer to evaluate the new program is provided.

System Implementation Schedule

Based on interviews with in-plant quality control personnel, there are 5 systems chosen for the pilot implementation program. The pilot period is 10 working days to operate the partial program and 10 working days to evaluate and adjust. The systems chosen are: 3B) sidewall framing, 4) wall setting on floors, 8A) rough electrical, 11B) doors and windows, and 12B) interior finishes. These systems were chosen because they were the top five ranking deficiency areas on table 2.1. A minimum total of 40 complete units will be inspected during the pilot period. This number is based on a production history of 20 units per week.

The implementation plan consists of the following steps:

1) At the beginning of the first day, each of the affected system crews will be instructed on the purpose and content of the specifications, procedures, and inspections for each system. At the beginning of each of the nine work days afterward, 10-15 minutes will be spent at the beginning of each day for questions and review.
2) Prior to start of work on each unit, the quality control inspector shall review additional/special inspection

requirements with each of the crew foremen. The review should include the specifications, procedures, and types and frequencies of inspections as a minimum.

3) During daily reviews, the inspector shall solicit comments from each crew and complete the evaluation form illustrated in figure 5.1 as the input is received. This will generate evaluation documents on the affect of the revised program on the production workers.

4) As work progresses, the foremen and quality control inspectors shall complete the inspection forms (see fig. 4.3) and the evaluation form illustrated in figure 5.2. This form is the first-hand evaluation of the program from the primary users.

5) At the conclusion of <u>each</u> week, all program inspection and comment forms will be submitted to the plant manager for review and comment. The plant manager also completes a copy of figure 5.2 to provide management input on production impacts. An important response is recorded on inspection staffing.

6) The entire package of inspections and comments are forwarded to the quality control, production, engineering, and sales division directors for review and comment. Management review time should not exceed one work week.

PRODUCTION CREW EVALUATION AND COMMENT FORM

SYSTEM_____ DATE_____
INSPECTOR_____ PILOT DAY_____
FOREMAN_____ CREW SIZE_____

INTERVIEW WORKERS AS A GROUP (CREW) EACH MORNING AND RECORD THEIR ANSWERS TO THE FOLLOWING QUESTIONS

Do you understand inspection requirements?
Do you understand what is being inspected?
Was anything not inspected that should have been inspected?
Was anything inspected that does not need inspecting?
Have you been delayed by inspections?
Does the foreman inspect your work prior to QC inspection?
Other comments.

FIGURE 5.1

Production Crew Evaluation and Comment Form

INSPECTOR/FOREMAN EVALUATION AND COMMENT FORM

INSPECTOR_____ DATE_____
FOREMAN_____ PILOT DAY_____

SYSTEMS INSPECTED_____

INSPECTORS AND FOREMEN SHALL COMPLETE THIS FORM DAILY, PLANT MANAGER SHALL COMPLETE WEEKLY

BE SPECIFIC, ONLY ANSWER THE QUESTIONS WHEN YOU HAVE A COMMENT

Were you able to perform all inspections required for all work?
Are specs and procedures accurate? What changes would you make?
Are inspection requirements accurate? What changes would you make?
Do all specifications, procedures, inspection requirements,and drawings match up well? What changes would you make?
Any other comments related to quality control? (be specific)

FIGURE 5.2

Inspector/Foreman Evaluation and Comment Form

Based on this review, the decision should be made by the quality control division director to maintain the program as is, or make adjustments. All changes shall be coordinated by the director, be written in 1 work week, and be re-implemented on the same 6 systems used for the pilot period. This re-implementation should be evaluated for one additional work week or 20 units, whichever occurs first.

Provided no additional changes are required, each of the remaining systems should be brought into the program at a manageable rate which is proposed to be 4 per week. This will allow for gradual transition. Additional changes, when required, should be implemented and evaluated in a similar manner. Figure 5.3 is a flow chart of the implementation schedule.

Training and Staffing

Prior to pilot implementation, each quality control inspector and foreman shall spend a minimum of 20 hours reading and evaluating the written program. As part of each individual review, an estimate of required quality control staffing should be provided. This is important for staffing during the pilot period. Figure 5.3 should be used for comment. This training should be accomplished over a 60 day period.

The inspectors currently in the plant represent staffing for the pilot period. During this period, they will provide comment on figure 5.2 with their estimate of the inspection staffing required

SEQUENCE STEPS

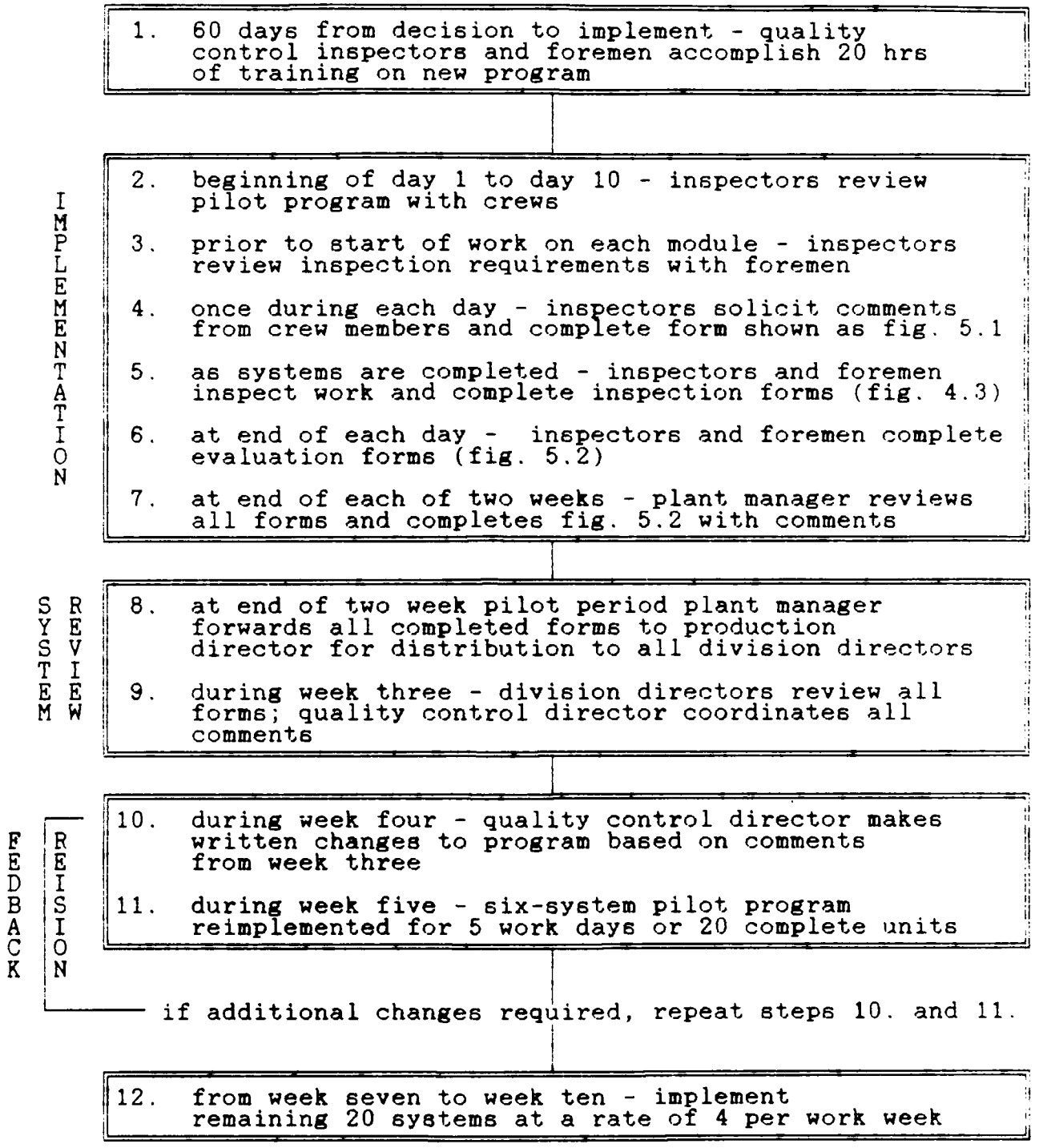


FIGURE 5.3

Pilot Period Implementation Flow Chart

once the program is fully implemented. The plant manager, quality control, production, and engineering directors should review estimates and recommend changes in permanent staffing when needed.

Qualifications of Inspectors

To be effective, inspectors must possess certain abilities as follows:

1) The ability to write clearly and accurately on a consistent basis. (17) Inspection reports that are inconsistent and difficult to read are useless.
2) Working knowledge of the applicable building codes. In order to spot design drawing or specification errors, the inspector must be familiar with the code requirements so that they can evaluate the plan requirements.
3) Complete objectivity. A current practice is to promote top performing production workers to positions of quality control inspectors. While this is an incentive for ambitious workers, the disadvantages should be considered. Inspectors in this situation, can have preconceived ideas based on their experience as production workers. These ideas can prejudice their judgement and their knowledge may be incorrect. Management must assure training of these individuals and ensure their objectivity.
4) Minimum educational achievement. While not an absolute

necessity, the manufacturer should institute a program whereby each inspector and foreman be given the opportunity to gain additional training. It will make the individuals more capable as leaders and communicators by providing them the tools they need to perform as professionals.

The Cost of Implementation

With the additional personnel and paperwork required, the administrative assistance to process the inspection information, and provided the required personnel training, additional administrative expense will be required. However, the manufacturer must weigh this cost against the benefits. Improved customer satisfaction, and reduced rework of deficiencies should be balanced against cost. In time, the program should pay for itself. (23) It is not possible though, to calculate the pay-back period, since this depends on how extensively the manufacturer implements the revised program and provides training to production and inspection personnel.

CHAPTER 6

SYNOPSIS

Summary

The modular manufacturing industry has a great need for a concise, practical, and innovative program to control product quality. The current state of in-plant quality control is not well organized. The overall program lacks specific monitoring and control documentation. Thus, the manufacturing inspection process remains somewhat primitive and nowhere near the level of control achieved in other constructed products. (9)

The program proposed in this report integrated the company quality assurance manual with the product manual. In addition, a method for properly documenting inspections was developed. This documentation provides the opportunity to evaluate quality deficiency trends within the plant.

The revised program usefulness will only be known after full implementation. The proposed program is based on a systematic evaluation of the existing system. Therefore, the proposed system can be implemented without a great deal of difficulty.

Systems Descriptions

The system descriptions were critical to organizing the proposed program. The original program employed 10 systems which were revised to more simplified divisions for easier definition and inspection. This allows for a more controlled system of inspection.

Although modeled around a particular manufacturing facility, this revised program is generic enough to be applicable to any modular plant. Since homes have the same component parts, the descriptions can be used universally. The product manual is sufficiently sectionalized to permit factory or product revisions without reorganizing the program's basic structure. The program can be assisted by a micro-computer system to manage data. Therefore, it can be employed by other manufacturers with slight revision based on specific assembly details.

Staffing

The level of quality control staffing is critical to the success of the program, regardless of its size. Unfortunately, there is no guidance or reference to estimate proper staffing levels. It would have been desirable to have accurate man-hour calculations to support a recommended staff level. The inspection staff has great difficulty completing all the required inspections at the current level. With the revised program, a staffing increase may be necessary.

The Affect of Change Orders

Overall, change orders were not observed to have detrimental affect quality. The inspection of change order work is addressed in the revised product manual.

Recommendations

This program should pave the way for a more integrated quality monitoring and control system for the modular manufacturer. The manufacturer can better control its resource allocation, inspection results, work methods, and similar opportunities. The goal of maximum output with minimal quality variation can be achieved.

However, with the introduction of any new program into an organization, resistance to change is inevitable. Therefore, management must be committed to the entire program. The program success can be achieved if management provides for:

1) review of all inspection documents by division directors on a frequent basis.
2) completion of training for all personnel and interim refresher courses.
3) minimum quarterly review of quality control program.
4) use of the program output to initiate changes in the plant.

Suggested Training

Quality control personnel should have better knowledge, training, and experience than production personnel. Higher qualification standards and training requirements must be established. While this is an extensive proposition, the quality improvement of the manufactured product will more than offset the cost. Both before and during in-plant implementation, training must be accomplished. Adequate personnel, including alternates must be trained so that continuity can be maintained should one or more of the regular inspectors be absent from duty. Table 6.1 is a partial listing of appropriate training topics appropriate for quality control inspection.

Future Research

Future research possibilities are as follows:

1) Monitoring implementation of this revised program through data collection and analysis would provide a measure of effectiveness over an extended time period.
2) Development of a deficiency coding system and computer based management information system for efficiently reporting the inspection data generated for management summary.

TABLE 6.1

Topics Listing for Quality Control Inspection Training

1. PURPOSE AND GOALS OF QUALITY CONTROL TRAINING
2. QUALITY CONTROL AND COMPANY RESPONSIBILITIES
3. CODE REQUIREMENTS
4. COMPANY ASSEMBLY REQUIREMENTS
5. TYPES OF INSPECTION PERFORMED
6. RECORD KEEPING REQUIREMENTS
7. ENGINEERING DRAWING READING AND INTERPRETATION
8. BASIC MATHEMATICS OF QUALITY CONTROL
9. GENERAL WRITTEN CORRESPONDENCE SKILLS
10. VERBAL COMMUNICATION SKILLS
11. COMPUTER APPLICATIONS FOR QUALITY CONTROL

3) Complete integration of design drawings, specifications and inspection documents. A single manual representing the standard of practice will result.

4) Analysis of the effects of state and local codes on the design and construction quality of the modular unit. Such information can be used for background data for pre-emptive code deliberations.

5) Analysis of the impact of transport and handling on quality. Model guidelines for these practices can be established along with a program similar to the one in this report.

6) Development of a training program for certification of modular manufacturing quality control inspectors.

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Appendix A

Topical Outline For Revised Quality Assurance Manual

1. Purpose of Manual

    a. Definitions of product quality goals
    b. Abstract of purpose and goals of quality assurance
    c. Quality control definitions
    c. Relationship of this manual to product manual

2. Quality Control Policy

    a. Written statement by company president
    b. General divisions of the areas of quality control emphasis
        1. Administrative procedures
        2. Material
        3. Production
        4. Transportation and installation

3. General Organizational Chart

    a. Organizational Chart from president to division head level
    b. Definition of quality assurance responsibilities for each division head level: sales, engineering, production, quality control, and administration/comptroller

4. Quality Control Organizational Chart

    a. Organizational chart from quality control division head to in-plant quality control inspector level
    b. Statements of responsibility for each level

5. Plant Layouts

    a. Plan view drawings of all production facilities with all 26 building systems and material staging points identified
    b. Descriptions of average output and styles of homes produced in each facility

6. Work Flow Diagrams

    a. Flow charts of all work in each plant from material receipt to finish product on transport trailer

b. Notations of division responsible for each item on the flow charts

7. In-Plant Assignments and Responsibilities (Key Personnel)

   a. Listings, by plant, of plant managers, foremen, leadmen, and quality control personnel, with brief descriptions of specific responsibilities of each

8. General Record Keeping

   a. Copies of all inspection documents for:
      1. Material quality
      2. Production
      3. Site-installation
   b. Flow chart describing information processing throughout the entire organization
   c. Specific quality control documentation responsibilities for each division and plant

9. Independent Third Party or State Inspection Agency General Requirements

   a. Description of role and authority of the agency
   b. Documentation required to satisfy the agency
   c. Documentation produced by the agency
   d. Inspection procedures to be employed by the agency
   e. Agency key personnel listings
   f. Reinspection requirements in the event of unit rejection

10. Individual State Approval Documents and Certifications

   a. Procedures for unit approval for each state
   b. Copies of certificates from each state

11. Material Quality Policy

   a. Description of all materials purchased by brand name
   b. Acceptable quality levels for each brand of material
   c. Points of contact for each vender
   d. Vendor responsibilities for:
      1. Delivery
      2. Quality assurance
      3. Replacement of defective material
   e. Listing of material quantities to be maintained at central storage and at each plant

12. Site Installation Quality Control Responsibilities

    a. General quality control policy for site installation
    b. Manufacturer responsibilities
    c. Builder responsibilities
    d. Quality control documents required

13. Training Policies

    a. Required training for all plant managers, foremen, leadmen, and quality control inspection personnel
    b. Listing of current staffing and training levels to date (kept current on a quarterly basis)
    c. One calendar year advance training plan and schedule for all those with training deficiencies

14. Key Personnel Resumes and Qualifications.

    a. Resume and qualification data (quality control related) for each division head, plant manager, and quality control inspector

Appendix B

Topical Outline for Revised Product Manual

Part 1. Administrative requirements

- a. Purpose of Manual
  1. Statement of procedural and site installation quality control
- b. Explanation of all applicable codes and and variances imposed by each individual state
- c. Third part or state inspection procedures, with emphasis on key personnel, inspection frequencies and document processing
- d. Certification label processing
  1. Issuing procedures by company management
  2. In-plant personnel responsible for placing the certificates
  3. Documentation required
- e. Quality control documentation required for each state
- f. Procedures for implementing changes to the product manual
  1. Instructions for submitting manual changes to the quality control division head
  2. Change recording procedures

Part 2. Material Quality Control

- a. Specific procedures for inspection and acceptance of all incoming material at central storage and each plant
- b. Procedures for inventory control
  1. Personnel responsible
  2. Documentation required
  3. Material handling (staging layouts and damage prevention)
- c. Procedures for documenting rejected material

Part 3. Production Quality Control

- a. 26 building systems packages
- b. Procedures for maintaining files of inspection documents, specifications and procedures.

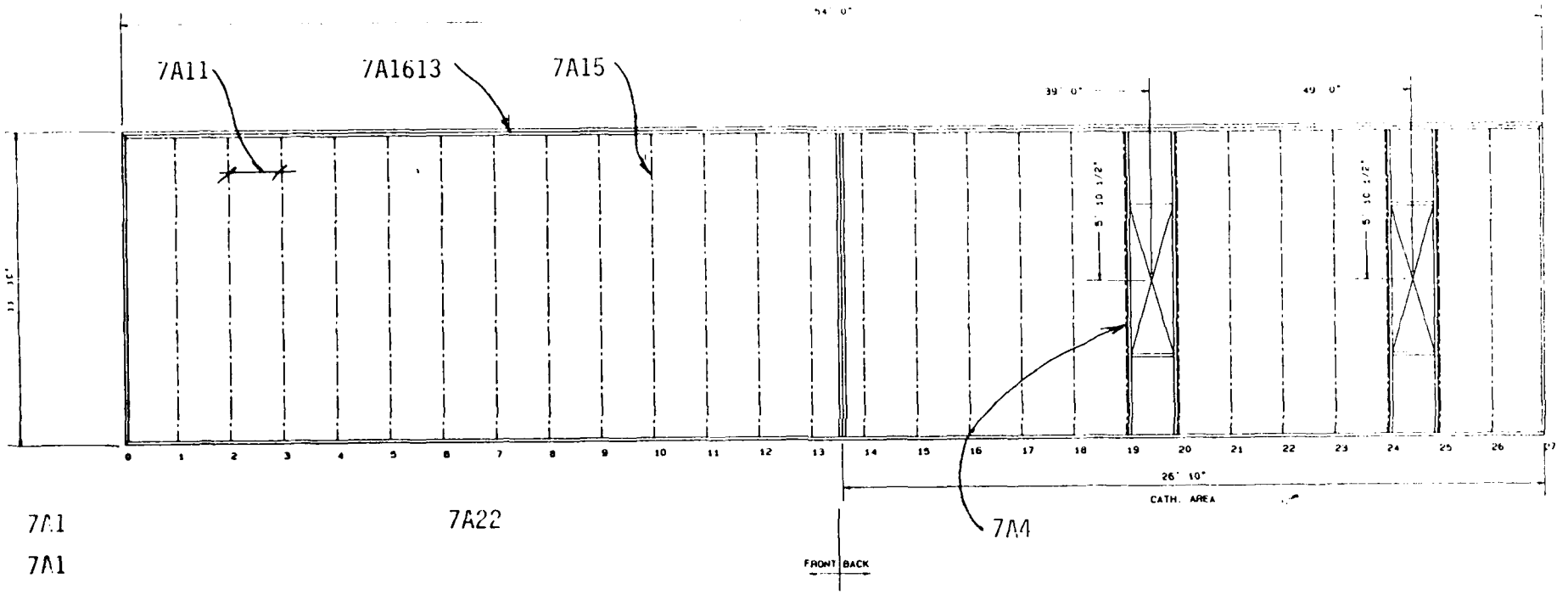
Part 4. Transport and Site Installation Quality Control

a. Shipping procedures
    1. Trailer regulations
    2. Wrapping requirements
    3. Transport and delivery documents required
b. Site erection guide
    1. Site erection system packages
        a. Inspection procedures
        b. Specifications
        b. Documentation required
        d. Builder responsibilities

Appendix C

Typical Production Drawings for Roof Frame Building

Note: Work item numbers, as listed on tables 4.3 and 4.4, are shown where applicable.

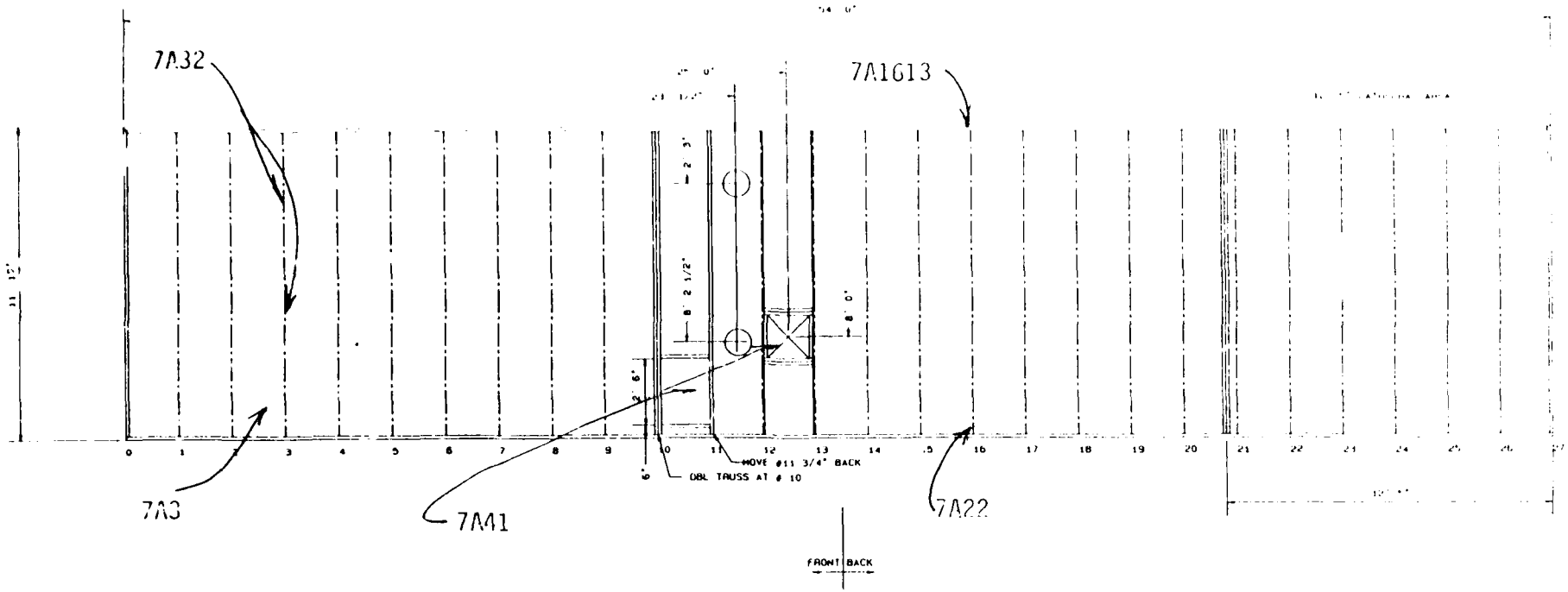


7A1

7A1

7A16

"A" UNIT CLG. FRAMING



"B" UNIT CLG. FRAMING

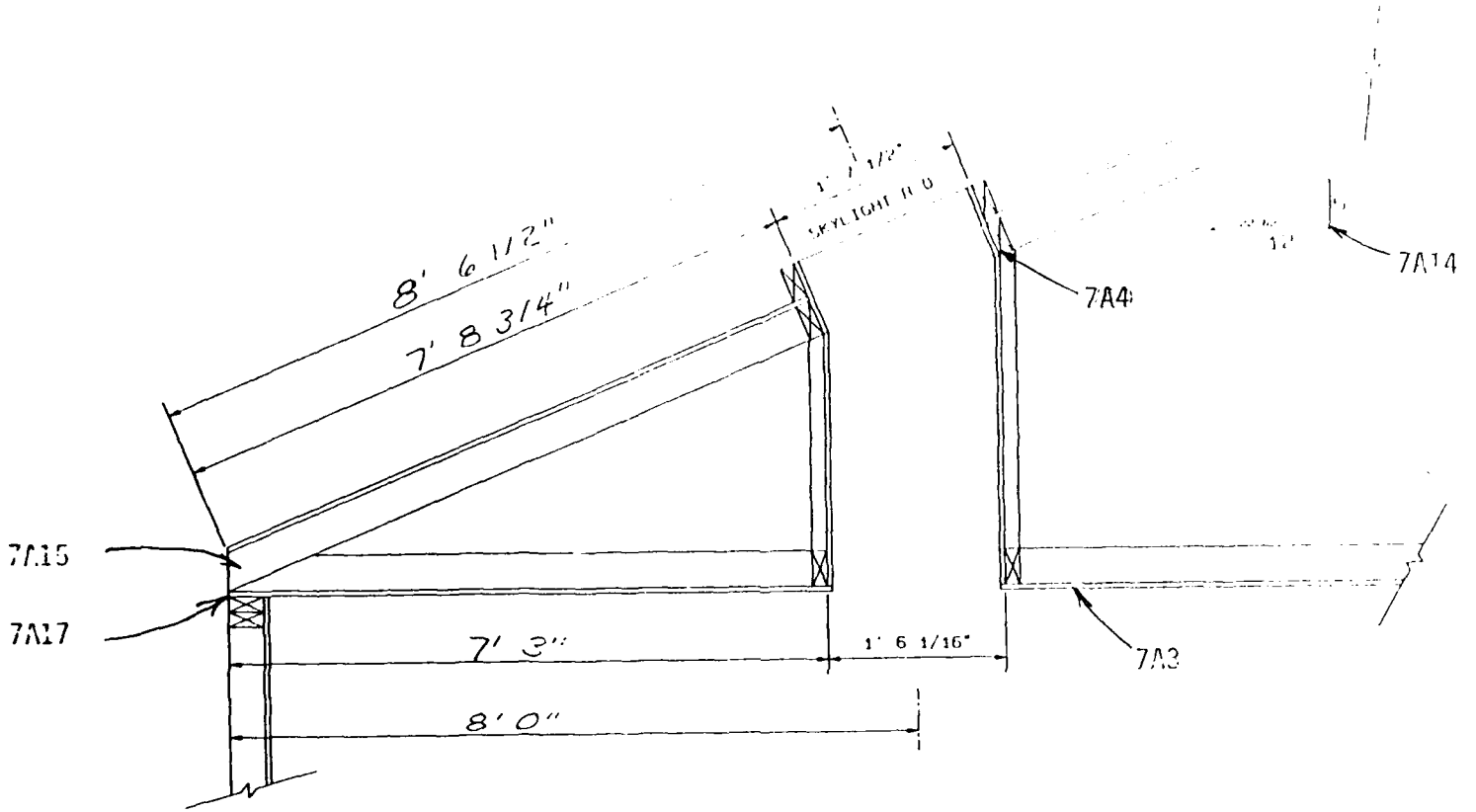
PENN LYON HOMES

FERNWOOD

DRWN BY | DATE

CONF BY | DATE

LEVEL | PLAN NO



SCALE: 1" = 1'0"

PENN LYON HOMES, INC.

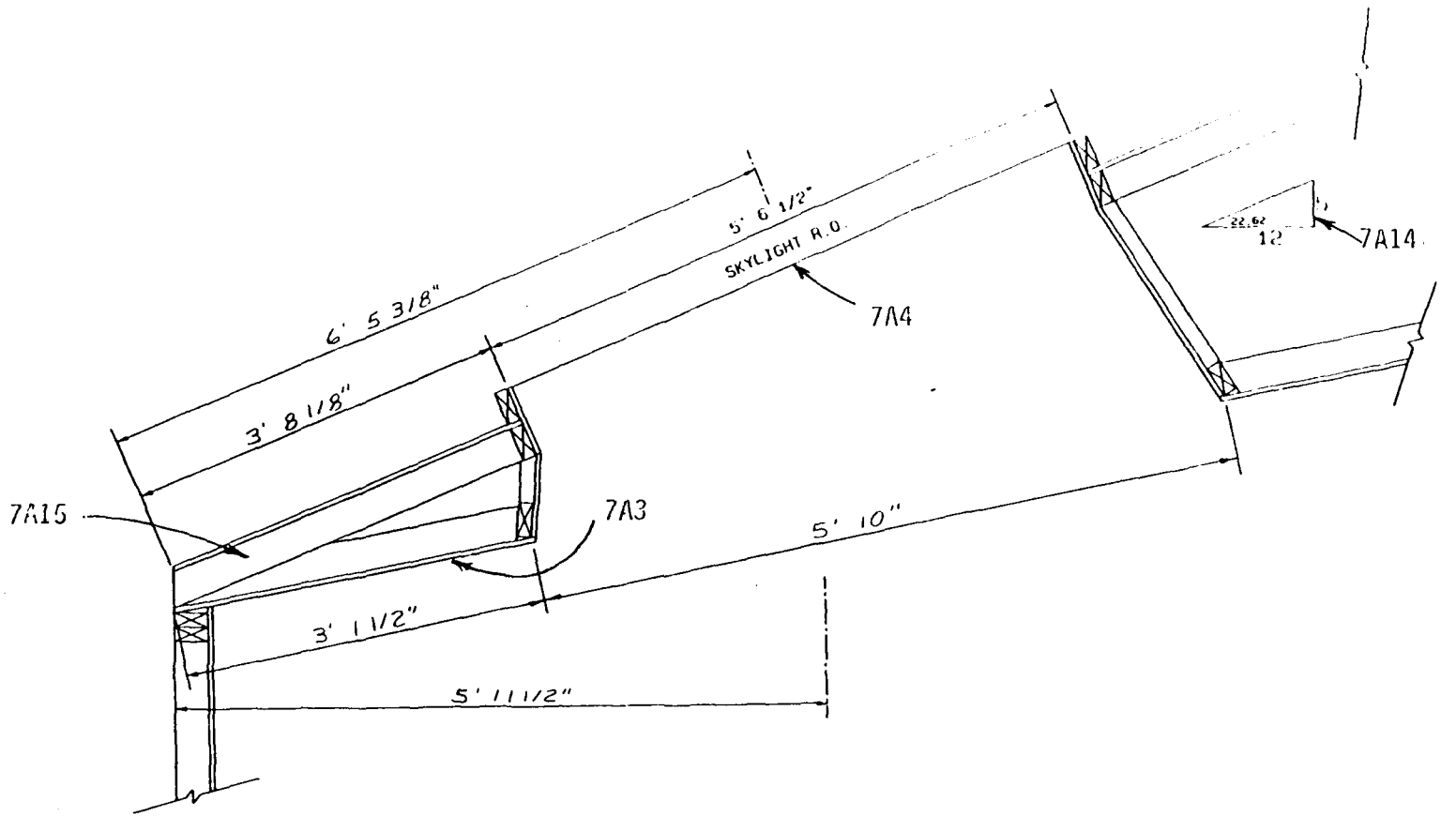
2X2 SKYLIGHT DETAIL

DRWN BY:

5/12 ROOF PITCH
FLAT CEILING

DATE

LEVEL | PLAN



SCALE: 1" = 1'0"

PLCH
PENN LYON HOMES, INC.

2X6 SKYLIGHT DETAIL

DRWN BY:	DATE:	
5/12 ROOF PITCH 11'10" CATH CLG FLARED SHAFT	LEVEL 6	PLAN NO